McGRAW-HILL ASTRONOMICAL SERIES
EDWARD ARTHUR FATH, Consulting Editor

A GUIDE TO THE CONSTELLATIONS

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First Edition
Second Impression

McGRAW-HILL BOOK COMPANY, Inc.
NEW YORK. 370 SEVENTH AVENUE
LONDON 6 & 8 BOUVERIE ST., E. C. 4
1928

PRINTED IN THE UNITED STATES OF AMERICA

THE MAPLE PRESS COMPANY, YORK, PA.

If the stars should appear one night in a thousand years, how would men believe and adore; and preserve for many generations the remembrance of the city of God which had been shown! But every night come out these envoys of beauty, and light the universe with their admonishing smile.

"*Essay on Nature*"—EMERSON.

Why did not someone teach me the constellations, and make me at home in the starry heavens, which are always overhead, and which I don't half know to this day?

CARLYLE.

PREFACE

This book has been prepared to meet the requirements of those who desire to become familiar with the constellations. Many are prevented from doing so by the lack of suitable material and instruction. Good charts are very necessary for this purpose; but their preparation is so difficult, and their size so much larger than the book page of ordinary dimensions that the constellations are often inadequately treated, if at all, in textbooks on astronomy. Such charts, globes, planispheres, and so forth as exist are not usually accompanied by sufficient explanatory and descriptive text to make them as useful as they should be. It is hoped that the present book, devoted exclusively to naked-eye observational astronomy, may serve this purpose and also be a valuable supplement to the regular textbooks on astronomy. It is written for the beginner but should prove to be a valuable reference book for all who are interested in the constellations.

Work on the charts was begun about six years ago and has continued intermittently from that time until their completion recently. The details of the method of constructing them will not be discussed, as they are technical and would probably interest few. The plotting has been based upon the most reliable data and has been done without reference to other charts except that the charts of Heis and of Gould have been consulted in respect to the Milky Way and the constellation boundary lines. Great pains have been taken to secure accuracy.

A very large number of books have been examined in the course of the preparation of the text. Special acknowledgement is made of the aid afforded by "Star-Names and Their Meanings," by R. H. Allen.

A copious index is given which the reader is advised to use freely. The authors desire to be notified of any errors, however trifling, which may be detected in the charts or in the text. They will also welcome criticism.

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WILLIAM H. BARTON, JR.

PHILADELPHIA, PA.
January, 1928.

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INTRODUCTION

"Two things fill my mind with ever new and increasing wonder and awe, the oftener and the more persistently I ponder over them, the starry heavens above me and the moral law within me," said the great German philosopher, Immanuel Kant. He was only expressing again the sentiment contained in the Nineteenth Psalm, written by King David about three thousand years before, "The heavens declare the glory of God . . . The law of Jehovah is perfect, restoring the soul," the Psalm paraphrased by Watts in his hymn, "The heavens declare Thy glory, Lord," and by Addison in his great hymn, "The spacious firmament on high." In all ages, the heavens have made deep and lasting impressions upon the minds of men.

The sky as it appears on a dark night, studded with stars, the "diamonds in the sky," has beauty which appeals even to those ordinarily indifferent to beauty. But it is more than a spectacle, it is more than beautiful; it is wonderful. It invites thinking, pondering, study; and these produce reverence. It is full of mystery. The astronomer who has delved into its mysteries has more unanswered questions concerning it than one who has never given it any thought.

"Up above the world so high," yes, the stars are at distances such that all adjectives—immeasurable, inconceivable, incomparable, incomprehensible—are alike hopelessly inadequate to express them. They are not twinkling sparks, as they seem, but in most cases, bodies of such great mass and volume that our minds cannot comprehend them, moving with velocities of many miles a second. "Look now toward heaven, and number the stars, if thou be able to number them . . . So shall thy seed be" (Gen. 15:5) and "I will multiply thy seed as the stars of the heavens, and as the sand which is upon the seashore" (Gen. 22:17) express the common belief that the stars are innumerable. In this particular only is the truth overestimated. The number of stars seen with the naked eye at one time and place is about two thousand only, not more than the population of a small town, nor more than the number of persons in many audiences and not more than the number of persons many are able to call by name. But it would require a lifetime to count the stars which can be seen with a great telescope.

David wrote in the Eighth Psalm, "When I consider thy heavens . . . What is man, that thou art mindful of him?" We can but wonder what he would have written had he considered the heavens in the light of our present knowledge, as set forth even in this book, for example, instead of in that of his day. The force of his question is vastly different now.

Before us in the sky we have a majestic moving system. How does it work? What are the laws governing its motions? These have been problems of the ages, for the earliest records show that men even then were trying to solve them, and, although great progress has been made, the solutions are still far from completion.

The greatest step in the solutions was the discovery of the law of universal gravitation by Isaac Newton, published in 1687. Newton is conceded to have been the greatest thinker who has ever lived. No praise has seemed too high for him. On his tomb in Westminster Abbey are written, in Latin, the words meaning "Let mortals congratulate themselves that so great an ornament of the human race has existed." But Newton said, "If I have seen further than other men, it is because I have stood on the shoulders of giants." Quoting from our greatest American astronomer, Simon Newcomb (1835–1909):

> In no other science (than astronomy) has each generation which advanced it been so much indebted to its predecessors for both the facts and the ideas necessary to make the advance . . . The great astronomers of all ages have built upon foundations laid by their predecessors; and when we attempt to search out the first founder, we find ourselves lost in the mists of antiquity. The theory of universal gravitation was founded by Newton upon the laws of Kepler (1571–1630), the observations and measurements of his French contemporaries, and the geometry of Apollonius (about 225 B.C.). Kepler used as his material the observations of Tycho Brahe (1546–1601), and built upon the theory of Copernicus (1473–1543). When we seek the origin of the instruments used by Tycho, we soon find ourselves among the mediæval Arabs. The discovery of the true system of the world by Copernicus was only possible by a careful study of the laws of apparent motion of the planets as expressed in the epicycles of Ptolemy (about 150 A.D.) and Hipparchus (about 150 B.C.) . . . If we seek the teachers and predecessors of Hipparchus, we find only the shadowy forms of Egyptian and Babylonian priests, whose names and writings are entirely lost.[1]

[1] From *Popular Astronomy*, by Simon Newcomb, copyright 1882 and 1910. Reprinted by permission of the American Book Company, Publishers.

"Contemplated as a whole," said the great French astronomer, Pierre Laplace, "astronomy is the most beautiful monument of the human mind, the noblest record of its intelligence."

The purpose here is simply to call attention to the sublimity of the problems presented by the celestial motions and to the fact that the marvellously accurate predictions now made, in the case of an eclipse of the sun, for example, are possible only because of the work of a long line of distinguished scientists.

The following quotation from Sir William Hamilton's "Lectures on Metaphysics," presents man from a different point of view: "On earth there is nothing great but man; in man there is nothing great but mind."

The heavenly bodies move with the precision of clockwork—no, with greater precision, for our clocks are regulated and set by the positions of the heavenly bodies. Human ingenuity has yet to devise a mechanism which will run with the precision with which the stars seem to revolve about the earth, due to the earth's rotation.

It is commonly supposed that some great and mysterious force must constantly be applied to keep the heavenly bodies in motion. Such is not the case. They move in empty space where there is no resistance to their motions, and they will continue moving, as they now do, forever, unless some force is applied. Another common but erroneous notion is to the effect that something or somebody must have started the motion. There is nothing in nature known to be at rest; therefore, rest, not motion, is unnatural (*i.e.* not like nature) and needs explanation.

We wonder what has been the origin of the universe and what its destiny will be, for we must think of an earlier state and a later state very different from that now existing; but here science at present can help little, for the period over which recorded observations extend is so extremely brief, compared with the ages required in the life histories of stars, that such matters remain in the realm of speculation.

Then, too, as one looks at the stars, he may muse over the fact that these same stars have been mentioned in some of the most ancient literature extant. Homer, Hesiod, and the author of the Book of Job wrote about them. They have furnished inspiration to the poets from their day to the present and probably to the poets of still earlier times. From these stars the imaginations of men of prehistoric times formed bears, a lion, a bull, and other creatures, familiar and grotesque, and these constellation figures, to be discussed later, form "the oldest picture book of all." Thus, the stars connect us with the past. More unchangeable are they than anything else we know.

Enough has been said to show that when one looks at the stars he has something to think about as well as to see, something too great for the greatest intellects to understand. Thinking about these things, even to a slight extent, is a profitable use of the mind. We shall now proceed to a detailed discussion of the sky, that the reader may be enabled to have that background of familiarity with its stars and its simpler motions which will make it more beautiful. But before doing this, a few things should be said about the earth.

THE EARTH

The earth is nearly a perfect sphere, 7,920 miles in diameter and 24,900 miles in circumference. It is slightly flattened at the poles, the diameter joining the poles being 27 miles shorter than a diameter at the equator. Its highest point, Mount Everest, is only 29,000 feet (5.5 miles), $\frac{1}{1,440}$ of the diameter of the earth, above sea level. Nearly three-fourths (72 per cent) of the surface is covered with water. The earth rotates on its axis once in a day, and this causes a point at the equator to move with a velocity of 17.3 miles a minute and a point in the United States (latitude 40 degrees) to move 13.3 miles a minute. It revolves around the sun in a path which is nearly circular, the radius of the circle being 92,900,000 miles (the distance to the sun) and the circumference, 584,000,000 miles. This means that the earth moves in its orbit at the rate of 18½ miles a second. The velocity with which the projectiles left the muzzle of the great gun with which the Germans bombarded Paris in the World War was only 1.1 miles a second. The velocity of the earth is about seventeen times as great.

The earth is kept in its orbit by the great attraction of the sun. If this attraction should cease and the earth be kept in its orbit by a rod connecting it with the sun, the rod, if made of steel of such a grade as to be able to support 50 tons to the square inch and if circular, must be at least 5,000 miles in diameter, or the earth would break it. Although the sun pulls so hard on the earth, the earth does not fall into it because its rapid motion in its orbit produces a centrifugal force which balances the pull of the sun. If the motion in the orbit were stopped, the earth would fall into the sun. It would move very slowly at first—only ⅑ inch in the first second—but it would fall into the sun 2 months later, moving with a velocity of 380 miles a second. Five-sixths of the time would be consumed in the first half of the fall.

Where are the largest telescopes located? is a question often asked an astronomer. He replies that the largest reflecting telescope in the world has a mirror 100 inches in diameter and is at the Mt. Wilson Observatory and that the largest refracting telescope is at the Yerkes Observatory and has a lens 40 inches in diameter. The

inquirer then asks where these observatories are located. How shall the astronomer tell him?

The following information is given in a pamphlet issued by the Yerkes Observatory, regarding its geographical position:

> Latitude, 42°34′12.″64; Longitude $5^h54^m13^s.24$ west of Greenwich. The grounds are one mile from the post-office of the little village of Williams Bay, Wisconsin, and a mile and a quarter from the station, at the terminus of a branch of the Chicago & Northwestern Railway, 76 miles from Chicago.

The astronomer could tell him the latitude and longitude of the observatory. That would be an accurate, brief, and scientific answer. The numbers given locate it within 6 feet and not only give the location of the observatory but that of the great refracting telescope. But the inquirer would probably be none the wiser. In order to make himself intelligible, the astronomer, like the writer of the pamphlet, tells him that the observatory is near Williams Bay, Wis. Now he is understood. The man knows where Wisconsin is—he has seen it marked on his map of the United States many times. He is still more confident when told that the observatory is 76 miles northwest of Chicago. Chicago—why, who does not know where that great city is? Here we have illustrated two methods of location—a scientific method of universal application—by means of two numerical quantities called "coördinates"—latitude and longitude—and by stating the position relative to other positions which are well known. At sea, where there are no convenient reference points (landmarks) the second method is unsuitable. The ship in distress sending out an S.O.S. call states its latitude and longitude.

The inquirer has another question, Where is Mars now? Perhaps the astronomer is able to take him outside, point to it, and say, "There it is." This, of course, is the simplest method. But suppose that it is cloudy or that for some other reason, Mars cannot be seen at the time, how shall he answer? He could state its two coördinates, right ascension and declination, discussed in Part II of this book, corresponding to longitude and latitude. The astronomer, knowing these numbers, could go inside the observatory and, using the graduated circles on his instrument and his clock, point his telescope and be sure that when he put his eye to the telescope he would see Mars, if it were possible to see it at the time. Or he could use some system which gives its position relative to well-known positions. He could say, "Mars is in Ophiuchus, about 15 degrees east of Antares." If this language were not understood, it would be for the same reason that a person does not know where the Yerkes Observatory is upon being told that it is in Wisconsin, 76 miles northwest of Chicago, namely, a lack of knowledge of geography; but in the case of Mars, it would be a lack of knowledge of what has been called "the geography of the heavens," more consistently known as **"uranography."** It is the purpose of this book to give charts and instructions by means of which one can acquire this knowledge.

It gives one real satisfaction to be able to call some, at least, of the stars by name. When one travels far, the scenery on the earth changes greatly, the language and customs of the people are very strange, and he is a stranger in a strange land. But above him is the same moon and some, at least, of the stars that shone upon him in his homeland; and if he has made the acquaintance of the stars, they will greet him like old friends wherever he be, abating his lonesomeness.

The remainder of the book consists of three parts.

Part I contains charts and explanations suited to the needs of beginners in the study of the stars, who live in the United States, or corresponding latitudes. The expression "here" in this part means "in the United States" (more specifically, latitude 40 degrees). This part also contains the discussions of the sun, moon, planets, and other things which are not marked on the charts and of various other topics.

Part II, which likewise applies in the United States, contains more detailed information than Part I. It should be particularly helpful to those who are studying astronomical text books.

Part III treats particularly of those parts of the sky which are not seen from the United States. Readers of Part II and of Part III are supposed to be familiar with the preceding parts.

The **Conclusion** gives a list of books on astronomy for those who wish to do more reading.

PART I

THE CONSTELLATIONS VISIBLE FROM THE UNITED STATES. THE SUN, MOON, PLANETS AND SO FORTH. MYTHOLOGY

THE CONSTELLATIONS

A constellation is an area on the sky. Somewhat as the United States is divided into forty-eight states with irregular boundaries, varying greatly in shape, size, and importance, so the whole expanse of the sky is divided into constellations of varied shape, size, and importance; eighty-eight are now commonly recognized. The brighter and fainter stars may be compared to the larger and smaller towns of a state. All heavenly bodies—the sun, moon, planets, comets, and so forth, as well as the stars—always lie in one or another of these eighty-eight constellations. The constellations are of little importance except for objects visible to the naked eye. The general region included in a constellation is usually recognized by an association or a grouping of the brighter stars within it. These groups of brighter stars are also spoken of as constellations, and this is the sense in which the word is often used in what follows.

Primitive peoples, for unknown reasons, associated certain groups of stars with various living things and, in a few cases, with inanimate objects and gave names accordingly to these groups and made constellations of them. In only a few cases, does the name help in any way in locating the constellation, any more than the name of a state helps in locating the state. These ancient constellations did not fill the whole sky, so others have been added. Indeed, many other constellations and changes have been proposed from time to time and accepted by some but not by others, and thus, some confusion exists as to names and boundaries, but the differences in present usage are neither great nor important, and the International Astronomical Union has taken steps to remove them. A much better system of constellations might have been devised, but it is now almost impossible to change greatly a system which has been in use so long. Of the eighty-eight constellations forty-eight have come down to us from ancient times and were known to Ptolemy, 150 A.D., from whom our information with respect to them is chiefly derived. A considerable number of the new ones were formed to include the stars which were too far south to be seen by those who made the ancient constellations. There are many interesting myths connected with the latter. Some of these may be found later in the book.

The names of the constellations are given in the Latin language. English equivalents are used by some, but the Latin names are better, because they are used over the whole world and in all important astronomical literature.

It is only from places along the equator that all of the stars can be seen. In latitude 40 degrees eight-ninths of the sky can be seen but at the poles only half of it. Some of the constellations are small in area and have few bright stars in them and are, therefore, less important than others. Ursa Major, Centaurus, Hercules, and Virgo are very large constellations, and Sagitta, Equuleus, Scutum, and Crux are very small ones.

The boundaries of the constellations are marked on the detail charts. It must be understood that these boundaries are entirely artificial. There is nothing in the sky which can be compared even to the rivers and mountain ranges which, in some cases, form natural boundaries of states. There is no relationship between the stars of the same constellation other than that of direction. The stars within it differ enormously in their distances from us, in their brightness, both real and apparent, in their size, and all other characteristics.

MAGNITUDES

The **magnitude** of a star is a number which expresses the degree of its brightness. Ancient astronomers arbitrarily divided the stars which they saw, that is, those visible to the naked eye, into six magnitudes. About twenty of the brightest stars were classified as of the first magnitude and the faintest visible to them under good conditions, as of the sixth magnitude. Since that time it has become necessary to define the system more accurately and to extend it to stars not visible to the naked eye. A few stars are now classed as brighter than the first magnitude.

The magnitudes have been divided according to the decimal system, so that we may express them more accurately. Thus, we may express the magnitude as 2.4 or as 2.37. The general expression "stars of the second magnitude" includes all stars with magnitudes between 1.50 and 2.50, and so with the other magnitudes, except that "first magnitude" is often intended to include all stars brighter than the second. A star

of magnitude 1.0 is defined to be exactly one hundred times as bright as one of magnitude 6.0. A decrease, then, of five magnitudes, corresponds to an increase of one hundred times in the brightness. The number which multiplied by itself five times gives 100, that is, the fifth root of 100, is 2.51+, hence, a star of magnitude 1.0 gives 2.51+ times (roughly two and a half times) as much light as one of magnitude 2.0, and one of magnitude 2.0 gives 2.51+ times as much light as one of magnitude 3.0, and so on. A star which is a magnitude brighter than one of magnitude 1.0 is of magnitude zero (0.0), and one a magnitude brighter still is of magnitude minus one (−1.0). Only Sirius, the brightest of the stars (magnitude −1.6), and Canopus, a star too far south to appear on these charts but which does appear on the chart on page 62, have minus magnitudes. Some of the planets, however, and, of course, the sun and moon have minus magnitudes. The magnitude of the sun is −26.7 and that of the average full moon, −12.5. The faintest star which can be seen with our present telescopes is of magnitude 19, but stars of magnitude 22 have been photographed.

The magnitudes of the brighter stars are given in Table IV, page 12. It may be seen that Vega is of magnitude 0.1; Altair, 0.9; Aldebaran, 1.1; Alkaid, 1.9; Polaris and Alpheratz, 2.1; and so these stars are samples of zero-, first-, and second-magnitude stars. A **variable star** is one of which the brightness varies and, hence, one of which the magnitude is not always the same. In some cases, it is well known that the variation in brightness is due to the fact that there are two stars present which eclipse each other at regular intervals. Such stars are called "eclipsing variables." A **double star** is one which consists of two stars too nearly in the same direction to be seen separately with the naked eye, even if bright enough. Unless stated otherwise, the magnitude given for such stars represents their combined light.

STAR NAMES

There are many occasions when we wish to speak of the individual stars which form a constellation. This is particularly true of the brighter stars. Many stars have been given special names, such as Arcturus, Rigel, Castor, and those which have been stated above. Only a small percentage of the names assigned, however, are in common use. We shall use all the special names used in the *American Ephemeris and Nautical Almanac*, astronomical publication of the United States Government, with occasional mention of others. The Ephemeris list with the pronunciations, and so forth, will be found in Table IV, page 12. Seventeen of these twenty-nine names are of Arabic origin. The others are of Greek or of Latin origin. Special names for approximately 225 stars are given by Allen in "Star Names and Their Meanings."

A system which is commonly used for naming stars was introduced by Bayer in 1603. He assigned the small letters of the Greek alphabet, in order, to the stars of each constellation, roughly in the order of decreasing brightness. We do not know the details of his method. When he had used all of the twenty-four letters of the Greek alphabet, he employed the Latin (our) alphabet similarly, except that he used the capital *A* to avoid confusion with the first letter of the Greek alphabet. Since that time, other capitals, numerals, and so forth, have been introduced to designate other stars. The Greek alphabet may be found on page 51.

In naming the stars, the genitive case of the Latin name of the constellation is used with the Greek or Latin letter. Thus, Altair, which is alpha of the constellation Aquila, is also called Alpha Aquilæ; Algol is Beta Persei; Bellatrix is Gamma Orionis; and Alcor is *g* Ursæ Majoris. As already stated, the special names are used only for a few stars, chiefly the brighter ones. There are no names for the other stars in common use except those of Bayer's system. In order to use these names, it is necessary to know the Greek alphabet, especially the first letters which designate the brighter stars, and the endings of the names of the constellations in the genitive case. Many, and particularly those just beginning the study of the constellations, seldom have occasion to use the Greek letters, and so, to avoid confusion and congestion, they have not been put on the charts of Part I. The special names of the brighter stars which are shown on each chart will be found on the page facing the chart. Bayer's system is used in the text when references by name to other stars are desirable.

THE CELESTIAL SPHERE

The principal heavenly bodies are the sun and moon and the stars. The stars are of two kinds, the fixed stars and the planets. The **fixed stars** are those which make up the constellations and which, so far as the naked eye can detect, remain in exactly the same positions, relative to each other, for a lifetime. Telescopes, however, reveal very slow motions of the so-called "fixed stars." These stars are bodies shining by their own light, and our sun is merely one of them, the "day star." With the naked eye we can tell nothing about their distances, except that they are very far away. We appear to be at the center of a large hemisphere, or dome, to which the stars are attached, all at the same distance from us. It is easily imagined that there is another similar hemisphere below the horizon to make up a complete sphere. This imaginary sphere, called the **celestial sphere,** is supposed to have an infinitely large radius.

The word **planet,** from the Greek, means "wanderer," that is, a wandering star in distinction from a fixed star. The planets, although they resemble the fixed stars, change their positions among them. They are dark bodies, which, like the earth, revolve about the sun and shine only because they reflect the sunlight which falls upon them. There are but six, other than the earth, visible to the naked eye (including Uranus which is usually invisible) and one which is not. We shall discuss them more fully later. The word **star** is used more specifically to include the fixed stars only.

The celestial sphere can be represented by a small model, a "celestial globe," just as we represent the surface of the earth on the globes used in the schoolroom. Just as we use maps in place of globes to represent parts of the earth's surface, so we can use maps to represent parts of the sky. No map either of the sky or of the earth is entirely correct, because the surface of a sphere cannot be flattened out without distortion into a flat surface such as a map. But globes, although accurate, are more costly than maps and much less convenient. The distortion of a map is usually greatest near its edges. There are many ways of making a map. The use to which it is to be put largely determines which is the best kind. In each of the accompanying maps or charts we wish to represent that half of the celestial sphere which is above the horizon, that is, the part of the sky which is visible, at a given time, in latitude 40 degrees north.

MOTION OF THE CELESTIAL SPHERE

The rotation of the earth on its axis causes the sun and moon to rise and set and likewise causes the whole celestial sphere with the stars to appear to make a complete rotation, in the direction east to west, each day. This apparent rotation of the celestial sphere must take place about the axis upon which the earth actually turns and in the opposite direction. The earth's axis extended until it meets the celestial sphere, meets it in two points called the **north and south celestial poles,** which correspond to the poles of the earth. The celestial sphere seems to turn around these poles in the same way as the earth turns about its poles but in the opposite direction. In northern latitudes we can see the north celestial pole only. Of course, there is nothing in the sky to mark its position. There is a star, however, quite close to the pole which for that reason is named **Polaris,** commonly called the "North Star." This star is the one at the free end of the curved or broken line in the constellation Ursa Minor, shown on each chart. Examination of the charts will show how the stars in their different positions seem to turn around this one (Polaris), which is almost exactly in the same position on each chart. In this connection the discussion of Polaris and of Ursa Minor given on page 18 should be read. The north pole, which is near Polaris, is exactly north and at an angle above the horizon equal to the latitude of the observer. These charts are made for latitude 40 degrees north (the latitude of Philadelphia). Inasmuch as the parallel of 40 degrees north latitude runs through the middle of the United States, the charts, although not quite exact, will be accurate enough for the purposes for which they are intended anywhere in the United States.

The earth makes one complete rotation on its axis in 23 hours 56+ minutes, a **sidereal day.** In that time the celestial sphere also makes a complete rotation, and the stars come back to the same positions. Because of the earth's revolution about the sun, the sun requires nearly 4 minutes longer to make its circuit and be again in the same direction, say, south, namely, 24 hours, or a solar day.

THE CHARTS

We are at the center of the celestial sphere. Only half of it can be seen at any one time, for the other half is hidden by the earth. The line above which the heavenly bodies are visible is called the horizon. On land we can see down to the tops of trees or buildings, or perhaps down to the ground, and so the horizon is a very irregular line the character of which changes when we move. If the earth's surface were perfectly smooth, as it nearly is on the sea, the horizon would be a perfect circle. Hereafter, we shall understand the **horizon** to be a perfect circle everywhere 90 degrees from the zenith. The **zenith** is the point in which the plumb line extended upward meets the celestial sphere, that is, it is the point exactly overhead. On Chart 1, we represent that part of the celestial sphere which is above the horizon, that is, the part which is visible, at 9 p.m., local time, on Jan. 15. The horizon is the circle which forms the boundary of each chart, and the zenith is the center.

The celestial sphere, however, is constantly turning and bringing other stars above the horizon and carrying below the horizon some which were visible, and only after 23 hours 56+ minutes will the chart fit the sky again. The stars then will rise, set, or be in any given position nearly 4 minutes earlier on each succeeding night, that is, 2 hours earlier in a month, and will get back to that position at the same time of night after a year. The 12 charts show the stars which are above the horizon at 12 equal intervals of time. They represent the sky on the same night at intervals of 2 hours, and they represent the sky at the same time of night at intervals of a month. As it is to be supposed that the charts will be used chiefly in the early evening, each chart is given the name of the month in the middle of which it fits the sky at 9 p.m. As the 4 minutes per day

amounts to an hour in 15 days and 2 hours in 30 days, a month, **each chart nearly fits the sky at 10 p.m. at the first of the month the name of which it bears, at 9 p.m. at the middle of that month, at 8 p.m. at the end of the month, and at 7 p.m. at the middle of the following month. Thus, on the same night, each chart fits the sky 2 hours earlier than the one which follows it, and, conversely, 2 hours later than the one which precedes it.** Chart 1 follows Chart 12 as if it were Chart 13. By means of these principles, there should be little difficulty in finding the proper chart to use at any time, but the following table may help, especially for the late hours. Only the hours of darkness are given.

Rule.—*The number of the chart to be used at any time is the number, if any, in the line of the date nearest to that on which the chart is to be used and in the column for the hour nearest to that when the observing is to be done. If this place is vacant, the number below the vacant place is to be used.*

Example.—Which chart should be used Nov. 10 at 6.15 p.m.? Nov. 15 is the nearest date given in the table, and 6 p.m. is the nearest hour. There is a vacant place in the line for Nov. 15 in the column for 6 p.m. Ten is the number below the vacant place; hence, Chart 10 is the proper one to use.

TABLE I.—TABLE FOR SELECTING PROPER CHART

Date		Hour, p.m.								Hour, a.m.						
		5	6	7	8	9	10	11	12	1	2	3	4	5	6	7
January	1	..	11	..	12	..	1	..	2	..	3	..	4	..	5	..
	15	11	..	12	..	1	..	2	..	3	..	4	..	5	..	6
February	1	..	12	..	1	..	2	..	3	..	4	..	5	..	6	..
	15	12	..	1	..	2	..	3	..	4	..	5	..	6	..	7
March	1	..	1	..	2	..	3	..	4	..	5	..	6	..	7	..
	15	1	..	2	..	3	..	4	..	5	..	6	..	7	..	8
April	1	..	2	..	3	..	4	..	5	..	6	..	7	..	8	..
	15	2	..	3	..	4	..	5	..	6	..	7	..	8	..	9
May	1	..	3	..	4	..	5	..	6	..	7	..	8	..	9	..
	15	3	..	4	..	5	..	6	..	7	..	8	..	9	..	10
June	1	..	4	..	5	..	6	..	7	..	8	..	9	..	10	..
	15	4	..	5	..	6	..	7	..	8	..	9	..	10		11
July	1	..	5	..	6	..	7	..	8	..	9	..	10	..	11	..
	15	5	..	6	..	7	..	8	..	9	..	10	..	11	..	12
August	1	..	6	..	7	..	8	..	9	..	10	..	11	..	12	..
	15	6	..	7	..	8	..	9	..	10	..	11	.	12	..	1
September	1	..	7	..	8	..	9	..	10	..	11	..	12	..	1	..
	15	7	..	8	..	9	..	10	..	11	..	12	..	1	..	2
October	1	..	8	..	9	..	10	..	11	..	12	..	1	..	2	..
	15	8	..	9	..	10	..	11	..	12	..	1	..	2	..	3
November	1	..	9	..	10	..	11	..	12	..	1	..	2	..	3	.
	15	9	..	10	..	11	..	12	..	1	..	2	..	3	..	4
December	1	..	10	..	11	..	12	..	1	..	2	..	3	..	4	..
	15	10	..	11	..	12	..	1	..	2	..	3	..	4	..	5
January	1	..	11	..	12	..	1	..	2	..	3	..	4	..	5	..

ATMOSPHERIC ABSORPTION

The light from the stars must pass through the earth's atmosphere before it reaches our eyes, and in doing so, some of it is lost by absorption. The nearer to the horizon a star is, the greater the depth of atmosphere to be penetrated by its light, and the greater the loss. Thus, stars which may be seen easily when high in the sky may be seen with difficulty, if at all, when they have just risen or are about to set. A star which is 10 degrees above the horizon gives us no more light than a star a whole magnitude fainter, which is overhead. This absorption effect has been considered in making the charts. All stars are shown which give us as much light as stars overhead having a magnitude of 4.5. Therefore, there are not nearly so many stars shown near the edge of any chart, the horizon, where the absorption is large, as there are near the center. By adopting this plan, we not only show the stars as they are seen, but are able to put more stars on the charts near the center without congestion. The authors believe that these are the only charts made on this plan.

In a very few cases, it has seemed advisable to include stars fainter than the above limit of magnitude 4.5. One of the stars in the "Little Dipper" in Ursa Minor, for instance, is fainter than this, yet it seemed wise to represent it on some of the charts. The other cases of exception will be noted in the discussion of the constellations in which they occur. The magnitudes of the *Revised Harvard Photometry* have been used.

TWINKLING

The atmosphere is also the cause of the twinkling of the stars, or "scintillation," as it is also called. The air between the observer and the stars is in constant circulation, and this agitation of the air produces slight changes in the apparent positions of the stars and changes in color and brightness, all of which are included under the term "twinkling." The twinkling is greatest near the horizon and varies in intensity from day to day. Twinkling is not generally noticeable in the case of bodies which show discs, as do the sun, moon, and planets. The real discs of stars, even as seen with the most powerful telescopes, are too small to detect. They are dancing points and have no definite shape.

STAR SYMBOLS

Seven symbols are used to indicate the differences in the brightness of stars. They will be found at the bottoms of the charts. The symbol marked 0 is used for any star which, after allowing for the decrease in its brightness due to the absorption of its light by the earth's atmosphere, in the star's position, is still as bright as a star of zero magnitude (−0.5 to +0.4

inclusive), which is overhead. Symbol 1 is used similarly to represent stars which are as bright as stars of the first magnitude overhead, and so on. The only exception is that, because of lack of space, all of the Pleiades are represented by symbol 5. Variable stars are represented as of their maximum brightness, except those which become invisible to the naked eye. These are assigned symbol 5 and are shown only on the charts on which they are in their best positions. All variable stars represented will be mentioned in the discussion of the constellations in which they are. All that are ever as bright as our limit are mentioned and represented. Double stars are represented with their combined brightness. The different type of symbols used for the brighter stars makes them conspicuous on the charts, as they should be. No map, however, can represent the differences in the brightness of the stars accurately. The fainter stars will appear more conspicuous than they should be. Here each symbol except the last includes stars which may differ nearly a whole magnitude in brightness, and no attempt is made to make finer distinctions. It would probably help little to try to do so.

USE OF THE CHARTS

After having decided upon the time at which he plans to observe, the reader should select the proper chart, making use of Table I, page 7 for the purpose. He should then familiarize himself with this chart. As previously stated, the circular boundary represents the horizon, and the center is the point overhead, the zenith. Four points on the horizon are marked: north, south, east, and west. It is assumed for the present that the observer knows these directions. It may be noticed that east is on the left side of the chart, whereas on maps of the earth, it is on the right side. The reason for the difference is that the earth is represented as seen from the outside, whereas the celestial sphere is represented as seen from the inside.

In looking at the sky, one is attracted first by the brighter stars, as a rule. These serve as points of reference. On the charts, the bright stars are made conspicuous by special symbols. The names of the bright stars shown on each chart are given at the top of the page facing the chart. The stars are given in order of decreasing brightness, not considering the absorption, the second column following the first. If the star is near the horizon, it may not have a special symbol, but it will usually be the most conspicuous star shown in the constellation. Notes are given in doubtful cases.

Lines are drawn on the charts connecting the stars which belong to the same constellation. In some cases, where it is obvious to which constellation the star belongs, it is not connected; for instance, when the star is enclosed between lines. These lines might have been drawn in various ways, but we have tried as far as possible to draw them so that it will be easy to remember how they lie. In some places, there are lines which run from stars of one constellation toward, but not quite all the way to, stars of another constellation. This indicates that if the star of the other constellation were included in the group to which it is not fully connected, it would make up a configuration easily described and remembered. Such cases occur in Pegasus, Auriga, and Draco. A fuller discussion is given in the description of those constellations.

The constellations are not always in equally good positions for study, even when entirely above the horizon. When near the horizon, some of the stars in the constellations become too faint to be seen, and all are fainter. They are in their best positions, that is, highest in the sky, when they are passing the line which crosses the sky from north to south, through the zenith. This line is called the **meridian.** On the chart, it is a line passing through north and south and the center of the chart. Facing each chart is a page containing a discussion of those constellations which are in their best positions on that chart. The discussion includes suggestions to help in tracing out the constellations in the sky, interesting bits of information about the stars in them, and so forth. The zodiacal constellation (defined on page 15) is discussed first, then those southward to the horizon, and then those northward to the pole. In discussing the celestial sphere, north means toward the north pole, and south, away from it; west means in the direction of the stars' daily motion, and east, the opposite direction. The constellations discussed in connection with the chart which precedes and with the one which follows the one most suitable are also in good positions. The constellations are arranged alphabetically in Table II, page 10, and the number of the chart on which each is in its best position is stated there.

THE MILKY WAY

On each of the charts, excepting 4 and 5, a stream of fine dots appears, crossing the chart. This represents the Milky Way. The Milky Way is a light, cloudy band in the sky. It encircles the heavens completely, but we can never see more than half of it at once, and some of it we never see. About half of the time it lies near the horizon and is not seen well, if at all. This fact accounts for its absence from the two charts. It is wide and diffuse in some places and narrow and relatively bright in others. In a considerable part of its course, it is divided into two branches. The true nature of the Milky Way is revealed by telescopes. It consists of an immense number of stars too faint to be seen separately with the naked eye, which are so closely packed that their combined light produces a

milky appearance. The general course and density are indicated on the charts, but the position of each dot is of no significance. Figure 1 is a photograph of a section of the Milky Way in the constellation Ophiuchus, which illustrates its nature. Each point of light is a star. None of these stars is visible to the naked eye. The Milky Way is also called the **Galaxy**.

FIG. 1.—The Milky Way in Ophiuchus. (*Photographed by Barnard of the Yerkes Observatory.*)

OUT OF DOORS

After one has read the discussion of the chart, and carefully examined it, he is ready to become an observer. If standing, he sees but a part of the sky—the part which he is facing. If he is facing south, he should hold the chart vertically in front of him, so that the word "south" on the chart is at the bottom. He will then see the stars in the relative positions shown on the chart; but if he is facing west, he should hold it so that the word "west" is at the bottom, and so with any other point of the compass. By turning and facing the four points of the horizon, he will see the whole sky. The names of the constellations are so placed that they will be in proper positions to read when the chart is held properly. The best position for viewing the sky, although inconvenient, is flat upon one's back. This view should be taken occasionally.

The observer should first try to pick out in the sky the bright stars named at the top of the page facing the chart. This should be easy to do. He must bear in mind, however, that there may be bright planets in view, and that their positions are not marked on the chart. It may be stated here that, if there are such, they will be near the curved line which crosses the chart. The matter is discussed fully, later. If there is doubt as to whether or not the right star has been picked out he should see if the stars nearby lie in the positions indicated by the chart, and if so, he should call the star by name and look for another bright star and then another, until several have been picked out and named, then go over his own list, if possible, without consulting the list or chart, until these stars become fixed in mind. After a few bright stars and groups have been identified, he can proceed step by step to fainter and more remote stars, until all have been picked out.

When the chart is used out of doors, a dim light should be used, merely bright enough to illuminate the part of the chart needed. A flash light covered with one or more folds of a handkerchief serves well. After using a bright light, the fainter stars are difficult to see. A person who knows the constellations can be very helpful to a beginner in constellation study, but the help should be in the line of checking rather than of direct instruction. A focusing flash light will be found very convenient for pointing out stars to others. The same stars and constellations should be picked out and named on different nights until they are thoroughly fixed in mind, for otherwise, they will soon be forgotten.

The reader has now been given enough instruction to enable him to use the charts for observation. He is advised to read pages 18 and 19 and then to begin observing at once, leaving the other parts of the book to be read as his time permits. Reading should be accompanied by observation. It is important that the book be read after some observing has been done, as well as before.

CONSTELLATION NAMES

Table II, which follows, gives in the first column, alphabetically, the names of the constellations which contain any of the stars represented on the charts (an asterisk after the name indicates that the constellation is one of the forty-eight listed by Ptolemy); the second column gives the pronunciation, and the third, the English equivalent, that is, the meaning of the name; the fourth gives the names of those stars in the constellations, for which we use special names; the fifth column

TABLE II.—TABLE OF CONSTELLATIONS

Name	Pronunciation	Meaning	Bright and important stars	Number of stars on charts	Best chart for study
Andromeda*........................	An-drom'e-da	Andromeda	Alpheratz	17	11
Aquarius*........................	A-kwā'ri-us	water carrier	....	15	10
Aquila*........................	Ak'wi-la	eagle	Altair	11	8
Aries*........................	Ā'ri-ēz	ram	....	5	12
Auriga*........................	A-rī'ga	charioteer	Capella	10	1
Boötes*........................	Bo-ō'tēz	Boötes	Arcturus	15	6
Camelopardalis........................	Ka-mel-o-par'da-lis	giraffe	....	4	1
Cancer*........................	Kan'ser	crab	....	6	3
Canes Venatici........................	Kā'nēz Vē-nat'i-sī	hunting dogs	....	2	5
Canis Major*........................	Kā'nis Mā'jor	larger dog	Sirius	14	2
Canis Minor*........................	Kā'nis Mī'nor	smaller dog	Procyon	2	3
Capricornus*........................	Kap-ri-kor'nus	horned goat	....	7	9
Cassiopeia*........................	Kas-i-o-pē'ya	Cassiopeia	Schedir	10	11
Centaurus*........................	Sen-taw'rus	centaur	....	4	6
Cepheus*........................	Sē'fūs	Cepheus	....	13	10
Cetus*........................	Sē'tus	whale	Mira	14	12
Columba........................	Ko-lum'ba	dove	....	2	2
Coma Berenices........................	Kō'ma Ber-e-nī'sēz	Berenice's hair	....	2	5
Corona Borealis*........................	Ko-rō'na Bō-re-ā'lis	northern crown	....	5	6
Corvus*........................	Kor'vus	crow	....	5	5
Crater*........................	Krā'ter	cup	....	3	4
Cygnus*........................	Sig'nus	swan	Deneb......	24	9
Delphinus*........................	Del-fī'nus	dolphin	....	5	9
Draco*........................	Drā'kō	dragon	....	15	7
Equuleus*........................	E-kwoo'le-us	colt	....	1	9
Eridanus*........................	E-rid'a-nus	Eridanus (a river)	....	14	12
Fornax........................	For'naks	furnace	....	1	12
Gemini*........................	Jem'i-nī	twins	Castor Pollux	19	2
Grus........................	Grus	crane	....	1	10
Hercules*........................	Her'ku-lēz	Hercules	....	24	7
Hydra*........................	Hī'dra	sea serpent	....	16	5
Lacerta........................	La-ser'ta	lizard	....	3	10
Leo*........................	Lē'ō	lion	Regulus Denebola	17	4
Leo Minor........................	Lē'ō Mī'nor	smaller lion	....	3	4
Lepus*........................	Lē'pus	hare	....	9	2
Libra*........................	Lī-bra	balance	....	7	6

TABLE II.—(*Continued*)

Name	Pronunciation	Meaning	Bright and important stars	Number of stars on charts	Best chart for study
Lupus*	Lū'pus	wolf	....	5	6
Lynx	Links	lynx	....	6	3
Lyra*	Lī'ra	lyre	Vega	10	8
Monoceros	Mo-nos'e-ros	unicorn	...	8	3
Ophiuchus*	Of-i-ū'kus	serpent bearer	....	17	7
Orion*	Ō-rī'on	Orion	Betelgeuse, Rigel, Bellatrix	25	2
Pegasus*	Peg'a-sus	Pegasus (a horse)	Markab	15	10
Perseus*	Per'sūs	Perseus	Algol	24	12
Phœnix	Fē'niks	phœnix	...	1	11
Pisces*	Pis'ēz	fishes	.....	11	11
Piscis Austrinus*	Pis'is Aus-trī'nus	southern fish	Fomalhaut	1	10
Puppis	Pup'pis	stern of a ship	.....	7	3
Pyxis	Pyx'is	compass	.	1	3
Sagitta*	Sa-jit'a	arrow	.....	4	9
Sagittarius*	Saj-i-tā'ri-us	archer	......	14	8
Scorpius*	Skor'pē-us	scorpion	Antares	17	7
Scutum	Skū'tum	shield	.....	1	8
Serpens*	Ser'pens	serpent	....	13	7
Taurus*	Taw'rus	bull	Aldebaran, Alcyone	29	1
Triangulum*	Trī-ang'gu-lum	triangle	...	3	12
Ursa Major*	Er'sa Mā'jor	larger bear	Alioth, Alkaid, Mizar, Alcor	22	4
Ursa Minor*	Er'sa Mī'nor	smaller bear	Polaris	8	6
Vela	Vē'la	sails	....	1	3
Virgo*	Ver'gō	virgin	Spica	15	5
Vulpecula	Vul-pec'u-la	little fox	....	1	9

shows the number of stars of the constellation represented on the charts; the last gives the number of the chart on which the constellation is in its best position and in connection with which it is discussed.

Table II contains sixty-one constellations. Six other constellations are entirely above the horizon, at times, but contain no stars bright enough to be shown on the charts. They are Antlia, Cælum, Corona Australis, Microscopium, Sculptor, and Sextans. Parts of the following six constellations are above the horizon at times but never the whole constellation, and they contain no stars which are represented on the charts: Ara, Horologium, Indus, Norma, Pictor, and Telescopium. Some stars in the following seven constellations are represented, but the entire constellation is never entirely above the horizon: Centaurus, Eridanus, Fornax, Grus, Lupus, Phœnix, and Vela. These are contained in Table II. The following fifteen constellations, none of which is ever above the horizon, even in part, complete the total of eighty-eight constellations: Apus, Carina, Chamæleon, Circinus, Crux, Dorado, Hydrus, Mensa, Musca, Octans, Pavo, Reticulum, Triangulum Australe, Tucana, and Volans.

NUMBER OF STARS

There are on the charts 584 different stars, the average number on a chart being 259. Table III shows the number of stars on the various charts.

TABLE III.—NUMBERS OF STARS ON MONTHLY CHARTS

January	274	July	268
February	270	August	260
March	270	September	271
April	224	October	261
May	226	November	268
June	240	December	277

Many more stars can be seen, of course, under good conditions, but on hazy or moonlight nights frequently not so many. The faint stars far outnumber the bright ones. On a clear, dark night, at one time and place,

about two thousand stars can be seen with the naked eye. Many suppose this number to be enormous. To state the facts more definitely, the number of stars in the whole celestial sphere brighter than magnitudes 2.0, 3.0, 4.0, 5.0, and 6.0, respectively, are 40, 135, 450, 1,500, and 4,800. There are about 880 of magnitude 4.5 or brighter. The number which could be photographed with the most powerful telescope now existing, the 100-inch reflector at Mt. Wilson, Calif., is about a billion (1,000,000,000). About half as many could be seen with the eye, using this telescope. The total number of stars in our system of stars has been estimated to be 30,000,000,000. The sun is one of these stars and a fair sample. Many stars are known to be more, and many to be less brilliant.

A LIGHT YEAR

A "light year" is the unit in which the distances of the stars are usually expressed. It is the distance which light travels in a year. As light travels 186,285 miles in a single second and there are $60 \times 60 \times 24 = 86{,}400$ seconds in a day and 365.256,36 days in a year, then light travels $186{,}285 \times 86{,}400 \times 365.256{,}36$ miles in a year, and this is the number of miles in a light year. With more than sufficient accuracy, we may express the result as 5,880,000,000,000 miles, that is, nearly six trillion miles. This is 63,300 times the distance from the earth to the sun, yet the distance to the sun, 92,870,000 miles, is no small distance. There are 63,360 inches in a mile, so a light year is as big compared with the distance of the sun as a mile is when compared with an inch. An airplane traveling 3 miles every minute would require 58.9 years to travel a distance equal to that to the sun and 3,726,000 years to travel a light year. A train traveling a mile a minute would require three times as long. Most watches tick five times a second. If a mile were traveled at each tick of the watch, 215 days, that is, 7 months, would be required in reaching the sun and 37,260 years in traveling a light year.

TABLE IV.—TABLE OF STARS

Name	Pronunciation	Constellation	Magnitude	Best chart for study	Distance light years	Luminosity	Greek letter
Alcor	Al'kor	Ursa Major	4.0	4	93	18	....
Alcyone	Al-sī'o-nē	Taurus	3.0	1	466	1,190	η
Aldebaran	Al-de-ba-ran'	Taurus	1 1	1	57	103	α
Algol	Al'gol	Perseus	Var.	12	121	....	β
Alioth	Al'i-oth	Ursa Major	1.7	4	78	107	ϵ
Alkaid	Al-kād'	Ursa Major	1 9	4	.....	....	η
Alpheratz	Al-fe-rats'	Andromeda	2.1	11	.....	....	α
Altair	Al-ta'ir	Aquila	0.9	8	16	9	α
Antares	An-tā'rēz	Scorpius	1.2	7	125	428	α
Arcturus	Ark-tū'rus	Boötes	0 2	6	41	112	α
Bellatrix	Bel'a-triks	Orion	1.7	2	172	515	γ
Betelgeuse	Bet-el-gerz'	Orion	1.0	2	192	1,225	α
Capella	Ka-pel'a	Auriga	0.2	1	43	130	α
Castor	Kas'tor	Gemini	1.6	2	42	24 11	α
Deneb	Den'eb	Cygnus	1.3	9	652	10,470	α
Denebola	De-neb'o-la	Leo	2 2	4	32	11	β
Fomalhaut	Fō'ma-lō	Piscis Austrinus	1 3	10	24	14	α
Markab	Mar'kab	Pegasus	2.6	10	86	58	α
Mira	Mī'ra	Cetus	Var.	12	52	....	o
Mizar	Mī'zar	Ursa Major	2.2	4	86	67 16	ζ
Polaris	Po-lā'ris	Ursa Minor	2.1	6	466	2,570	α
Pollux	Pol'uks	Gemini	1.2	2	32	29	β
Procyon	Prō'si-on	Canis Minor	0.5	3	10.5	6	α
Regulus	Reg'u-lus	Leo	1.3	4	56	77	α
Rigel	Rē'jel	Orion	0.3	2	544	18,000	β
Schedir	Shā'der	Cassiopeia	2.5	11	204	356	α
Sirius	Sir'i-us	Canis Major	−1.6	2	8.8	28	α
Spica	Spī'ka	Virgo	1.2	5	362	3,600	α
Vega	Vē'ga	Lyra	0.1	8	26	51	α

But great as is the distance in a light year, no star except the sun is so near. The next nearest star, so far as we know, is Alpha Centauri, at a distance of 4.3 light years (see p. 64). Sirius, the nearest of the stars shown on the charts of Part I, is 8.8 light years away. This means that the light of Sirius leaves it 8.8 years before it reaches the earth and that we now see the star as it was 8.8 years ago. The light from the moon reaches us in 1.3 seconds and that of the sun, in 8 minutes 19 seconds and that from Neptune, the outermost planet, in 4 hours 10 minutes, on the average.

Table IV gives in the first column the special names of the stars visible here, which are in common use, arranged alphabetically; in the second column is given the pronunciation; in the third column, the constellation; in the fourth column, the magnitude; in the fifth column, the number of the chart on which the star is in its best position; in the sixth column, its distance in light years; in the seventh column, its luminosity; and in the last column, Bayer's Greek letter for the star. By **luminosity** is meant the brightness of the star in terms of the sun's brightness at the same distance. The luminosity of Sirius being 28, if Sirius were brought as close to us as the sun, it would give us twenty-eight times as much light as the sun does.

In the cases of Castor and Mizar, each of which consists of two bright stars too close together to be seen separately with the naked eye, the magnitude represents the combined light, but the luminosity of each star is given separately. "Var" indicates that the star is a variable.

Columns 6 and 7 of Table IV are based on the *Yale Catalogue of Parallaxes* (*Edition of* 1924). There is a large percentage of error possible in these quantities, especially for the distant stars, as the distances of such stars are very difficult to determine accurately. These are the most reliable values at the present time. The distance of Alkaid is not given by the catalogue, and that for Alpheratz is too uncertain to use.

It will be noted that all of the stars given have luminosities greater than 1, which, of course, is the luminosity of the sun. But only the brightest stars are included, and they are the ones most likely to have large luminosities.

Table V gives, in order of decreasing brightness, the names and magnitudes of the brightest twenty stars visible here.

Table V.—The Brightest Twenty Stars Visible Here

Name	Magnitude	Name	Magnitude
Sirius	−1.6	Antares	1.2
Vega	0.1	Fomalhaut	1.3
Capella	0.2	Deneb	1.3
Arcturus	0.2	Regulus	1.3
Rigel	0.3	Castor	1.6
Procyon	0.5	Epilson Canis Majoris	
Altair	0.9		1.6
Betelgeuse	1.0 to 1.4	Alioth	1.7
Aldebaran	1.1	Bellatrix	1.7
Pollux	1.2	Lambda Scorpii	1.7
Spica	1.2		

Aldebaran, Antares, Arcturus, and Betelgeuse have a noticeable red tinge, and Capella and Pollux, a yellow tinge.

Betelgeuse is a star with a volume 26,000,000 times that of the sun but having a mass only sixteen times as great. Its mean density is only a thousandth of that of air, which means that it is about as dense as a fair vacuum. A cube of such material, 23 feet on a side, would weigh only a pound. Near the other extreme is the companion to Sirius. Sirius is a double star of an unusual character. The brighter star gives out 10,000 times as much light as the fainter one but has only 2.5 times as much mass. The companion can be seen only with large telescopes. It is found to have a density 50,000 times that of water, about 4,500 times that of lead, and over 2,000 times that of anything known on the earth. A pint (liquid) of such matter weighs 26 tons; a ball of it the size of a tennis ball would weigh 7.4 tons. The star has almost exactly the same mass as the sun. Although some stars like Betelgeuse are millions of times as large as the sun, probably none has more than one hundred times as much mass. The most massive star known is one of which we can say that its mass is at least seventy-five times that of the sun, which, in turn, has a mass 332,000 times that of the earth.

THE SUN

Because of the revolution of the earth around the sun, the latter appears to move eastward among the stars, about a degree, which is twice its apparent diameter, in a day and completely around the celestial sphere, once each year. This apparent path of the sun among the stars is called the **ecliptic.** Half of the ecliptic is shown on each chart as a line crossing it. Although the ecliptic seems to lie in a different position on each chart, it will be found to lie in exactly the same place among the stars on each of them. The circle on the celestial sphere, which is just halfway between the poles and which corresponds to the earth's equator, is called the **celestial equator.** Small sections of the celestial equator, near the points where it intersects the ecliptic, are shown. The ecliptic intersects the equator in two points, one of which lies in the constellation Pisces and the other, in the constellation Virgo. About March 21, the sun is at the point in Pisces, moving northward, and about Sept. 23, it is at the other point—in Virgo—

moving southward. These points are named, respectively, the **vernal equinox** and the **autumnal equinox.** The points at which the sun is farthest north, in Gemini, and farthest south, in Sagittarius, are named, respectively, the **summer solstice** and the **winter solstice,** and they are marked on the charts by short lines perpendicular to the ecliptic. The sun is at these points about June 21 and Dec. 22, respectively.

The sun is the nearest of the stars. The earth revolves about it at the rate of 18½ miles a second in an orbit which is nearly but not exactly circular. The mean distance of the sun is 92,900,000 miles. In January, when nearest, its distance is 1,500,000 miles less, and is greater by the same amount in July. The sun's diameter is 864,000 miles, which is 109.1 times that of the earth, and its volume is 1,300,000 times that of the earth. Its temperature is equivalent to 10,000°F. (6,000°C.).

The sun is so overpoweringly brilliant that the other stars cannot be seen with the naked eye when the sun is above the horizon. The impression that they can be seen from the bottoms of mines, chimneys, wells, and so forth, in the day time is incorrect. The brighter planets may be seen with the naked eye, however, and stars may be seen with telescopes. Occasionally, the dark spots (sun spots) which are usually present on the sun, are large enough to be seen without a telescope. One should never attempt to look at the sun without ample protection for the eyes, as its light is so strong that it is likely to cause permanent injury. Very dark smoked or stained glass may be used, or, even better, an exposed and developed photographic plate. The phenomena which may be seen at the time of eclipses of the sun will not be discussed here.

THE MOON

The moon also moves eastward among the stars, and makes the complete circuit of the celestial sphere in a month. It does not move in exactly the same path in successive revolutions, and so its path cannot be shown on the charts, but it may be said that the moon is never seen at a greater distance than 6 degrees (or a trifle more) from the ecliptic, sometimes north of it (above), and sometimes south of it (below).

The moon is a body 2,160 miles in diameter, which revolves about the earth in an orbit that is nearly circular, at the rate of 38 miles a minute. It is the nearest of the heavenly bodies. Its mean distance is 239,000 miles, but the distance may be as great as 253,000 or as small as 221,000 miles. It is one forty-ninth as large as the earth in volume. It subtends an angle of 31′, that is, just a little more than half a degree, and it moves about this distance among the stars in an hour. The moon and the sun appear almost of the same size to us. Because of their variations in distance, sometimes the disc of the moon is larger, sometimes that of the sun, and at some eclipses of the sun, the moon completely covers it while at other eclipses, it is not large enough to do so.

The moon, like the earth and other planets, has no light of its own but shines only because the sun shines upon it and because it reflects that light. It is for this reason that the moon has phases. The cause of the phases will now be explained in more detail, using Fig. 2. The figure is not drawn to scale. The moon is about a quarter as large as the earth in diameter and is

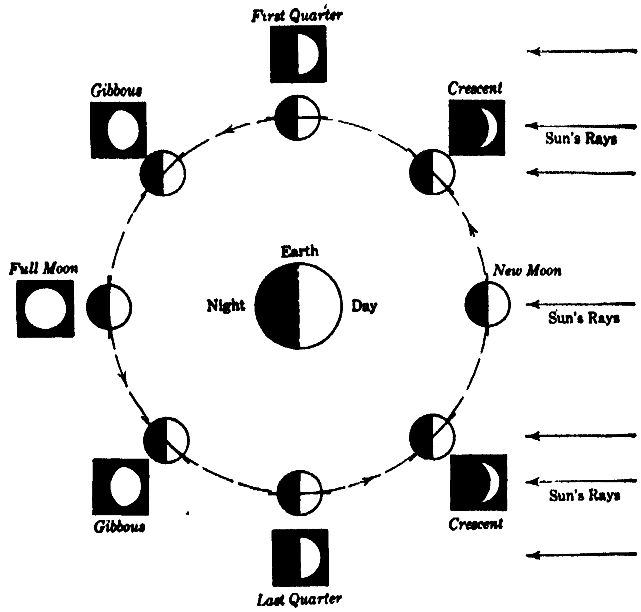


Fig. 2.—Phases of the Moon.

thirty times the diameter of the earth from it. The sun is 389 times as far away as the moon. The rays of the sun illuminate half of the earth at any one time, and that half, of course, has daylight. The atmosphere of the earth however, reflects a little light to places a little beyond the daylight half. This section has twilight. It is represented in the figure by the shaded section. The rest of the earth has night. The half of the moon toward the sun, similarly, has daylight, and the other half has night. As there is no appreciable atmosphere on the moon, there is no twilight zone there.

The figure shows arrows on the right-hand side to indicate the rays of light from the distant sun. These illuminate the half of the earth and the half of the moon on that side. The moon is shown in eight positions in its orbit thus illuminated, as seen from a direction perpendicular to the plane of the orbit. The moon, however, is viewed from the earth. The observer can see but half of it at one time, the half toward him. Through the moon in each position is drawn a diameter extending slightly outside it, marking the boundary of the half which he could see if it were illuminated. In the posi-

tion marked "new moon," none of the half toward the earth is illuminated, and, hence, the moon is invisible. Of course, it could not be seen in the face of the sun, anyway. When the moon has moved to the next position shown, about 4 days later, a part of the half illuminated by the sun is in the half which could be seen from the earth, and the moon is seen as a crescent of the form shown nearby. After 7 days, the moon has reached the position at the top of the figure marked "first quarter," where half of the half illuminated by the sun is visible. At full moon, all the part illuminated by the sun is visible from the earth, and so the full disc is seen.

Here one may inquire why the earth does not prevent the light from reaching the moon. Sometimes it does. Then the shadow of the earth falls on the moon, and an eclipse of the moon occurs. Such an eclipse can occur only at full moon. It does not occur often, because, since the moon does not move in the ecliptic, the sun, earth, and moon at this time are generally not quite in a straight line. Similarly, at new moon, the moon may come exactly between the earth and the sun and cause an eclipse of the sun, but generally, it does not. If it does, the moon's shadow falls on the earth. For the discussion of eclipses, the reader is referred to textbooks on astronomy.

The appearance of the moon, when it is in each of the eight positions of the orbit represented, is shown. The cusps (points) are always turned away from the sun. From last quarter to first quarter, the moon is "crescent," and from first quarter to last quarter, when more than half of the disc is visible, it is "gibbous." The moon can be seen at some time of night every night, with the exception of about 5 days near new moon. The new moon crosses the meridian, that is, is south, at the same time as the sun—noon. The first quarter is south at 6 p. m.; the full moon, at midnight; and the last quarter, at 6 a. m. The moon goes through all of its phases, on the average, in 29.5 days.

Large, dark spots on the surface of the moon are conspicuous to the naked eye. From them, the imagination makes the man in the moon, the lady in the moon, a crab, rabbit, donkey, and so forth. These spots are great plains made of material which has not as high a reflecting power as have the other parts. It is a peculiar fact that the moon rotates on its axis in just the same time that it revolves about the earth, and for this reason, the same face of the moon is always turned toward the earth. There is a part which no one has ever seen.

As seen from the moon, the earth would go though similar phases, the bright part of the earth having just the same shape as the dark part of the moon. When the moon is new, the earth, to an observer on the moon, would be full, as is evident from the figure. Calculations show that the full earth gives out about forty times as much light as the full moon. When the light from the earth, nearly full, shines on the moon, then nearly new, it gives considerable illumination to that part of the moon turned toward it, and the crescent moon is seen brilliantly illuminated by the sun directly, and the remaining part of the disc, faintly illuminated by the earth shine. This is called "the old moon in the new moon's arms." It is indicated on the figure. After a few days, the intensity of the earth's light becomes less with its change of phase, and the intensity of the moon's, greater, so that it is not possible to see the fainter part of the disc.

The moon, as it moves over the sky, is always passing over some of the stars and hiding them. It is said to **occult** these stars. It may occult each of the planets and Aldebaran, Spica, Antares, and Regulus among the brighter stars. The occultation of a bright object is interesting to watch.

The sun gives us 466,000 times as much light as the average full moon. Since a hemisphere is 98,000 times as large as the area filled by the moon, if all the sky above the horizon were as bright as the full moon and shining as effectively in all parts, it would give us only a little more than a fifth as much light as the sun.

THE ZODIAC

The principal purpose in placing the ecliptic on the charts is to enable one to know where to expect to find the planets. Of course, there is no trouble in identifying the sun and moon. The planets revolve about the sun and so appear to move among the stars on the celestial sphere, so that their positions cannot be marked on the charts, except for a particular time. The apparent paths of the planets are complex, but, like the moon, the planets are never seen far from the ecliptic. Venus, which deviates most from it, is never more than 9 degrees away, and the maximum deviations of the other planets are less than the numbers as follows: Mars, 7 degrees; Mercury, 6 degrees; Saturn, 3 degrees; Jupiter, 2 degrees; Neptune, 2 degrees; and Uranus, 1 degree. Only in exceptional cases do the planets approach the wide limits.

The belt, or zone, of the sky, 18 degrees wide, bounded by lines 9 degrees from the ecliptic on each side, is therefore of especial importance, because the moving bodies, the sun, moon, and planets, are always within its boundaries. This zone is called the **zodiac.**

There are twelve constellations along the ecliptic. They are called the twelve **zodiacal constellations.** In order, they are Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpius, Sagittarius, Capricornus, Aquarius, and Pisces. These constellations, like all others, have irregular boundaries. They do not lie entirely within the zodiac. There are also parts of other constel-

lations within the zodiac; the principal ones are Ophiuchus, Orion, Cetus, and Auriga.

The zodiac has been divided into twelve sections, each exactly like the others, each 30 degrees long and as wide as the zodiac, beginning at the vernal equinox. These sections are called the **signs of the zodiac.** They are given the same names as the twelve constellations of the zodiac and in the same order. The one with the vernal equinox on its western limit is the sign of Aries. At one time, the signs and the constellations of the same name were in about the same positions, but now they are not, because of the precession of the equinoxes. The **precession of the equinoxes,** is a very slow movement of the equinoxes westward along the ecliptic. The rate is about 50″.2 a year. They make a complete circuit in about 25,800 years. The signs of the zodiac are now little used in astronomy.

THE PLANETS

The planets, unlike the sun and moon, cannot be distinguished from the fixed stars at a glance. They resemble them. They are even called "morning and evening stars." Yet there are several points of difference. The most conspicuous difference, of course, is that the planets move. But when one does not know which stars to suspect of motion, this is an unsatisfactory test, especially so, since all of the planets, at times, and the outer planets, always, change their positions slowly. The positions of the fixed stars are marked on the charts, but those of the planets cannot be, because they move; hence, if any starlike object is seen, which is not marked on the charts and is as bright as the stars shown it is surely a planet, excepting for the very rare occurrence of a "temporary star." Hence, it is particularly important to know the constellations of the zodiac, the only ones in which planets are to be found. Another difference is that the planets shine with a steady light and do not twinkle as the stars do. Beginners will probably feel somewhat in doubt in applying this test.

But even though it is known that the object seen is a planet, we have stated nothing which will enable one to decide which of the planets it is. The matter is further complicated by the fact that the planets vary in brightness as they change their positions with respect to the earth and the sun. The brightest of the planets is **Venus.** At its best, Venus has a magnitude −4.4, and when seen, it is always much brighter than any fixed star. It is often so close to the sun that it is not visible in the sun's glare. It is never seen more than 48 degrees away from the sun, so that, ordinarily, when it is seen, it is near the western horizon in the evening twilight or soon after or near the eastern horizon in the morning twilight or a little before. The planet is so bright that it is possible at times to see it in broad daylight, if one knows just where to look. Ordinarily, the next brightest planet is **Jupiter.** Its brightness varies from magnitude −1.2 to magnitude −2.5. Except when it is too near the sun to be seen, Jupiter is also brighter than any of the fixed stars. Saturn is usually third in brightness and **Mars** fourth but Mars is frequently brighter than Saturn, sometimes brighter than Jupiter and on rare occasions it is even brighter than Jupiter ever is. The magnitude of Mars varies from +2.1 to −2.7. It is reddish in color, which helps in identifying it. The magnitude of **Saturn** varies from +1.4 to −0.3. **Mercury,** like Venus, is never seen far from the sun—never more than 28 degrees from it. It may be seen only at special times, and then only in bright twilight, so it has not been considered in the above discussion of brightness. At its best, it sets soon after the sun or rises just a little before the sun. When brightest, its magnitude is −1.9. It is a bright object and easily seen, if one looks at the proper time. Under favorable conditions, the planet **Uranus** (Ū′ra-nus) is just visible to the naked eye. **Neptune** is always too faint to be seen with the naked eye.

Repeating, then, Mercury is seen only occasionally and then only in the twilight and near the horizon, setting soon after the sun or rising just before the sun. Venus, likewise, is seen in the twilight or shortly after in the evening or shortly before in the morning. It is conspicuously brilliant. The other planets, all of which are farther from the sun than the earth, may be seen at any point of the ecliptic or near it and are not necessarily near the sun in direction, as are Mercury and Venus, whose orbits lie inside that of the earth. Jupiter can be distinguished by its brightness. Mars is usually fainter than some of the fixed stars, and Saturn always is, yet both are bright. They are faintest when near the sun where they cannot be seen. The only stars in the zodiac which are brighter than magnitude 2.1, the magnitude of Mars at its faintest, are Aldebaran, Pollux, Spica, Antares, Regulus, Beta Tauri, and Gamma Geminorum. Aldebaran alone is ever brighter than Saturn. Mars is distinguishable by its red color. Therefore, it is only necessary to know these brighter stars within the zodiac to be able to distinguish these planets.

If the distance eastward from the sun to a planet is less than the distance westward, the planet is called an **evening star.** Stated otherwise, if a planet is south after noon and before midnight, or, less accurately, if it sets after sunset and before sunrise, it is an evening star. Otherwise, it is a morning star. Planets may be too close to the sun to be seen. This is usually the case with Mercury, often with Venus. The other planets are usually visible at some time of the night. The location of the planets at any particular time can be ascertained by the method described in Part II.

Some astronomical publications and newspaper articles on current astronomical events either give charts showing the locations of the planets at the time or statements as to the constellations in which they are. Names of a few such publications are given on page 70. It is very convenient to have such information, but it is not strictly necessary in the case of the brighter planets, except, possibly, to the beginner.

PLANETARY CONFIGURATIONS

When any two heavenly bodies pass each other in the sky, as seen from the earth, they are said to be in **conjunction.** When one body is in the direction opposite to that of the other, they are in **opposition;** and when 90 degrees apart, they are in **quadrature.** Unless stated otherwise, one body is understood to be the sun. Thus, the moon when it is new (see Fig. 2, p. 14) is in conjunction; at first quarter it is in eastern quadrature because it is then 90 degrees east of the sun; at full moon it is in opposition, and at last quarter it is in western quadrature. These positions are called **aspects.** The angle between the direction of a body at any time and that of the sun is its **elongation.** A body which is in conjunction crosses the meridian at the same time as the sun, that is, at noon; if in opposition it crosses at midnight; if at eastern or western quadrature, at 6 p. m. or 6 a. m., respectively.

The planets revolve about the sun in orbits which are nearly, but not exactly, circular with the sun at a common center. The two planets which are closer to the sun than the earth—Mercury and Venus—are called **inferior planets,** and the others, whose orbits lie outside that of the earth, are **superior planets.** A superior planet has the four aspects named—conjunction, opposition, and quadratures. An inferior planet has no opposition or quadratures. As it revolves about the sun it passes between the earth and the sun at **inferior conjunction,** and it also passes the sun when it is on the opposite side of the sun from the earth when it is at **superior conjunction.** The planet is closest to the earth at inferior conjunction and farthest from it at superior conjunction. In either case, it is too nearly in the direction of the sun to be seen. It may happen to pass exactly between the earth and the sun, in which case, the planet may be seen as a black, circular spot on the face of the sun. This phenomenon is called a **transit** of the planet. There is a transit of Mercury on the average once in 7 years, but the next two will occur in 1940 and 1953. Transits of Mercury cannot be observed without a telescope. There will be no transit of Venus until 2004. Because their orbits are small, the inferior planets are always in the general direction of the sun no matter in what part of their orbits they are, so that their elongations are never large. To see Mercury, which is the nearer to the sun and also the fainter of the two, one must select times when it is near its **greatest elongation** east or west. Venus can be seen best about the time of its greatest elongations, but it is so bright that it can be seen very easily when its elongation is much smaller. The times at which the planets are in their various configurations in any year are given in many almanacs for the year. The information may be obtained directly from the "American Nautical Almanac" (see p. 56) from which other almanacs copy the information. Greatest eastern elongations which occur in the spring, and greatest western elongations, which occur in the autumn, are the best, as the planet will then be farther from the horizon at sunset and sunrise, respectively, for any given elongation.

Superior planets can be seen at some time of the night except during a relatively short period near their conjunctions. In this period, they are faintest and farthest from the earth, anyway. They are nearest and brightest when near their oppositions. The great changes which occur in the distance of Mars, relatively, produce great changes in its brightness. The changes are much smaller in the case of the more distant planets. As the planets are illuminated by the sun, they show phases, but these cannot be seen with the naked eye. The inferior planets show all the phases. The superior planets are always so nearly full that a departure from the full phase can be seen only in the case of Mars.

An inferior planet is an evening star from superior conjunction to inferior conjunction; from inferior conjunction to superior conjunction it is a morning star. A superior planet is an evening star from opposition to conjunction, and a morning star from conjunction to opposition.

At what time of the year can Venus be seen? is a question often asked. A star, as already explained, is in the same position at the same time each year, but this is not true of a planet. The position of a planet in the sky depends upon its motion as well as that of the earth, and it bears no close relation to the time of the year. The most important factor to be considered is the elongation of the planet. The average interval in which a planet goes through all of its changes of elongation and returns to the same configuration, that is, the interval from conjunction to conjunction, for instance, is its **synodic period.** The synodic period of Venus is 584 days, or 1 year and 7 months. This planet is at its greatest eastern elongation and, hence, about at its best as an evening star, Feb. 7, 1929. The following greatest eastern elongation will occur about September, 1930. Mars has a synodic period of 780 days, or 2 years and 2 months. Its next opposition occurs Dec. 21, 1928, and so the

following one will occur early in 1931. The synodic period of Mercury is 116 days, or about 4 months. Those of Jupiter, Saturn, Uranus, and Neptune are each only a little over a year, namely, 399, 378, 370, and 367 days, respectively. Hence, these planets come to opposition almost every year and only a little later each year. Their oppositions in 1929 occur, respectively, Dec. 3, June 19, Oct. 3, and Feb. 19.

The times in which Mercury and Venus revolve about the sun, called their **sidereal periods** are, respectively, 88 and 225 days. Those of Mars, Jupiter, Saturn, Uranus, and Neptune are, respectively, 1.9, 11.9, 29.4, 84.0, and 164.8 years.

The inner planets move across the sky rapidly, and there is little use in stating where they are at a particular time other than the time of observation. Jupiter moves eastward about 30 degrees a year (although its motion is not always eastward); similarly, Saturn moves eastward about 12 degrees a year; Uranus, 4 degrees; and Neptune, only 2 degrees. At the times of their oppositions, in 1929, stated above, these planets are, respectively, in the constellations Taurus, Sagittarius, Pisces, and Leo.

A **satellite** is a smaller body revolving about a planet. The moon is a satellite of the earth. Jupiter has nine satellites four of which can be seen with very small telescopes.

Table VI, below, gives information about the planets and requires no explanation, except that the distances from the sun are mean distances.

TABLE VI.—FACTS ABOUT THE PLANETS

Planet	Distance from sun millions of miles	Distance from earth millions of miles	Diameter at equator in miles	Number of times volume of earth	Number of satellites
Mercury	36	50 to 136	3,000	0.06	0
Venus	67	26 to 160	7,700	0.92	0
Earth	93	....	7,927	1.00	1
Mars	141	35 to 248	4,215	0.15	2
Jupiter	483	367 to 600	88,600	1,300	9
Saturn	886	745 to 1,027	74,000	730	9
Uranus	1,782	1,605 to 1,959	32,000	64	4
Neptune	2,793	2,677 to 2,911	31,000	60	1

POLARIS—THE NORTH STAR

As has already been explained, the rotation of the earth on its axis makes the whole celestial sphere appear to rotate on the same axis in the opposite direction. All the stars appear to move around the poles as if they were attached to this large rotating sphere. The stars near the poles appear to move in small circles, and those farther away, in larger circles in such a manner that the constellations remain unaltered by the motion. The star Polaris, also called the "North Star" and the "polestar," is only a little more than a degree away from the north pole. The circle in which it appears to move is so small, that the change in its position is not easily noticed with the naked eye. The north pole of the heavens, of course, is above the point of the horizon which is exactly north, and the north star is always nearly so. As the north star circles about the pole, it is exactly north twice each day, that is, when it is above the pole and again when it is below the pole, and the farthest it ever is from true north in latitude 40 degrees is a degree and a half. Hence, if one is able to identify this star, he has a means of determining directions, and this is of great importance to one who is lost. The deviation of Polaris from true north at any time can be determined. If this correction is applied, the direction of true north can be determined accurately from an observation of the direction of Polaris.

The altitude of the pole (the angular distance above the horizon) is equal to the latitude of the observer, and the altitude of Polaris is nearly equal to the latitude. The correction at any time can be determined. If this correction is applied, the latitude can be determined accurately from an observation of the altitude of Polaris. Hence, the star is very important to astronomers, navigators, surveyors, and explorers.

Polaris is usually located by means of the stars of the Big Dipper. The Big Dipper is the name commonly applied in the United States to a group of seven bright stars in the constellation Ursa Major, which are so situated that they suggest the outline of a large dipper. Usually, these stars are easily found, and there is little chance of error in identifying them. When Chart 11 or 12 applies, the Big Dipper is too close to the horizon to afford a satisfactory view, but earlier or later on the same night, when some other chart applies, the Dipper may be seen better. No matter when it is seen, the line joining the two stars forming the side of the bowl of the dipper farthest from the handle, if extended five times its length, will end near Polaris. Hence, these two stars are commonly known as the "pointers." Polaris is of about the same brightness as the pointers, and there are no bright stars between. The pointers are about 5 degrees apart.

THE CIRCUMPOLAR CONSTELLATIONS

Since the celestial pole, in latitude 40 degrees, is 40 degrees above the horizon, stars which are less than 40 degrees from the pole will never set. The constellations near the pole are always entirely above the horizon or nearly so. These are called the "circumpolar constellations." We shall describe them here, because they will be found on many or all of the charts.

URSA MINOR

The north celestial pole and Polaris lie in this constellation. The constellation is found on each chart, and it is in its best position on Chart 6. Seven of the eight stars shown form what is known as the "Little Dipper."

Polaris is the bright star at the free end of the handle. The two stars which are farthest from the handle and which correspond to the pointers in the Big Dipper are also bright. These two stars are known as the "guardians of the pole," because they circle about it closer than any other conspicuous stars, Polaris excepted. Of the two stars at the bottom of the bowl of the Little Dipper, the one nearer to Polaris is fainter than the limit which we have adopted for the charts, but it is shown on a few charts where the Dipper is high in the sky, because of its important position. The Little Dipper is not nearly so easily found as the Big Dipper. Polaris and the guardians are seen easily. The other stars are inconspicuous and easily missed in slight haze or moonlight. On some of the charts, only Polaris and the guardians appear. The Little Dipper pours into the Big Dipper, and vice versa. Polaris (Alpha Ursæ Minoris) is a star of magnitude 2.1.

CEPHEUS

Cepheus is a rather inconspicuous, close, circumpolar constellation. As it contains no stars which are very bright, it is rather difficult to locate. Some of the stars form a crude square with a triangle having nearly equal sides resting on it, as may be seen from the charts. Cepheus is in its best position on Chart 10. The star which is farthest east of the group near the southern corner of the square (Chart 10) is Delta Cephei, a colored double star and the star which is taken as the type star for the large class called "Cepheid variables"; its brightness varies regularly in a peculiar manner from magnitude 3.7 to 4.6 and back in a period of 5.37 days. The star south of the middle of the southern side of the square (Chart 10) is Mu Cephei, the reddest star seen with the naked eye; its magnitude varies irregularly from 4.0 to 4.8. The first star west of the western corner of the square is Eta Cephei; it is approaching us with a velocity of 54 miles a second. This is greater than the velocity of approach of any other star shown on the charts, but some fainter stars have greater velocities, the largest known being 238 miles a second. The three stars mentioned are too faint to appear on all the charts. Cepheus lies in the midst of the Milky Way.

CAMELOPARDALIS

A part of Camelopardalis is quite close to the pole. There are but four stars bright enough to be represented on the charts, even when the constellation is in its best position (Chart 1). These stars are not very close to the pole. The brightest of the four is of magnitude 4.2. The constellation does not appear on charts 4 to 9, because, even though the constellation is entirely above the horizon, none of the stars in it is bright enough to be represented when it is near the horizon. Camelopardalis was formed to fill in a large region between the ancient constellations.

DRACO

Only a very minute part of Draco ever sets, and none of the stars shown on the charts lies in this part. The constellation is in its best position on Chart 7. Draco consists of a stream of stars, which, starting near the pointers in Ursa Major, between them and Polaris, makes a semicircle about the guardians of the pole and then turns back on itself and ends in a conspicuous quadrilateral which forms the "head of Draco." It is natural to associate the brightest three of these four stars with one in Hercules to form a neat diamond as shown on Chart 8. Draco is one of the few constellations for which the name, which means "the dragon," seems fitting for the arrangement of the stars in the constellation. The head of Draco lies between the very bright star Vega in Lyra and the guardians.

CASSIOPEIA

Only a small part of Cassiopeia ever sets, and none of the stars shown on the charts lies in this part. Five of the brighter stars of Cassiopeia are so situated that they mark out an irregular W or M, according to position. The constellation is usually identified by this "W in Cassiopeia." Cassiopeia is in its best position on Chart 11. The star of the W which is farthest from Polaris is called "Schedir." Its brightness varies irregularly from magnitude 2.2 to 2.8. Cassiopeia and the Big Dipper lie nearly on opposite sides of the pole, so that when the one is in poor position, the other is in good position for observation.

URSA MAJOR

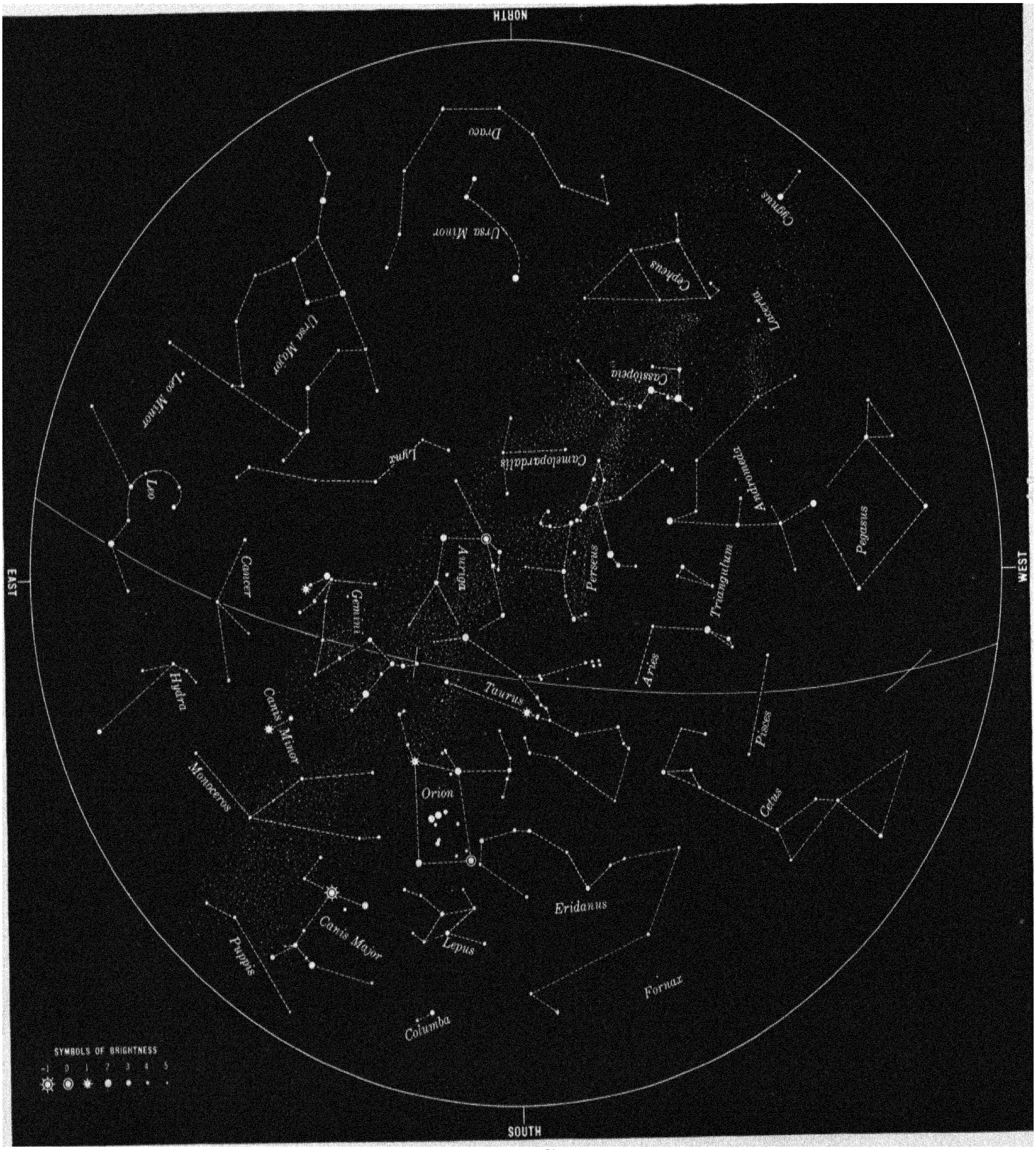
A considerable part of Ursa Major, including one of the stars of the Big Dipper, sets, so it will be discussed more fully in connection with Chart 4, on which it has its best position.

THE WINTER SKY

The sky in the early evening in winter contains many more bright stars than it does in summer. It is commonly supposed that this is because the atmosphere is clearer or that in some way it is due to the difference in temperature. This is not the case. There is a belt of bright stars, called "Gould's Belt," passing through the constellations Puppis, Vela, Carina, Crux, Centaurus, Lupus, Scorpius, Ophiuchus, Hercules, Lyra, Cygnus, Cepheus, Cassiopeia, Perseus, Taurus, Orion, and Canis Major. Numerous first-magnitude stars are found in the constellations from Perseus to the end of the list, which are in favorable positions in the winter time. They are just as bright when seen in other seasons late at night.

CHART 1

JANUARY



For use

January 15 from 8 to 10 p. m.

January 1, 9 11 p. m. **January 31, 7-9 p. m.**

For a later hour use Chart 2

For an earlier hour use Chart 12

See page 7

CHART 1

JANUARY

The following are the stars brighter than magnitude 1.5 shown on the chart:

SIRIUS in Canis Major
CAPELLA in Auriga
RIGEL in Orion (lower star)
PROCYON in Canis Minor
BETELGEUSE in Orion (upper star)
ALDEBARAN in Taurus
POLLUX in Gemini
DENEB in Cygnus
REGULUS in Leo

TAURUS

Within the constellation Taurus are two smaller groups of stars to which names are applied. The more important of these is called the **"Pleiades"** (Plī'a-dēz). This is the very compact cluster of six stars shown on the chart. As many as sixteen stars of the cluster have been seen with the naked eye, some, however, rather remote, but most persons see only six. Many more are seen with opera glasses and telescopes. The Pleiades are sometimes called the "seven sisters." The brightest star of the group is called "Alcyone." It is of magnitude 3.0. The next brightest is nearly a whole magnitude fainter, 3.8, and the faintest of the six is of magnitude 4.4. None of these stars would be conspicuous if alone, but, clustered as they are in this remarkable manner, they attract the attention more quickly then does a bright star. Some of the stars are represented in positions where they are fainter than our limit. The Pleiades have been worshiped, temples have been erected to them and calendars regulated by their positions. They are among the few astronomical objects mentioned in the Bible (Job 38:31). They are better known than the constellation in which they are located.

The brightest star in Taurus is Aldebaran, which means the "follower." The name probably refers to the fact that the star follows the Pleiades. Its magnitude is 1.06; hence, it is a good example of a first-magnitude star. Aldebaran with the other fainter stars near it form what is commonly known as the "V in Taurus." Six of these stars constitute the other group referred to, the **"Hyades"** (Hī'a-dēz). The star next to the top of the upper branch of the V is not included. There are other fainter stars near by. The nearest two stars to Aldebaran are interesting, because so near each other. The Hyades, except Aldebaran, which appears to have no real connection with the others, and other stars constitute the "moving cluster in Taurus." These stars form a globular cluster, 33 light years in diameter, which moves through space with a velocity of 28.6 miles a second relative to the sun. The center of the cluster is 130 light years away, and some of the stars in it are as much as one hundred times as bright as the sun. Aldebaran is a reddish star and the brightest in the zodiac. It has a diameter of 33,000,000 miles, which is thirty-eight times that of the sun. It is one of four bright stars about equally distributed along the ecliptic which are called "Royal Stars." The others are Regulus, Antares, and Fomalhaut. Aldebaran, Rigel, Betelgeuse, and Sirius form a large diamond.

The star, which, with the V in Taurus, makes a Y, is Lambda Tauri, a well-known eclipsing variable star. Its magnitude varies from 3.3 to 4.2 and back regularly in a period of 3.95 days. Twenty-nine stars in Taurus are shown on the chart. No other constellation on any of these charts has so many. Few of the stars are conspicuous, however.

AURIGA

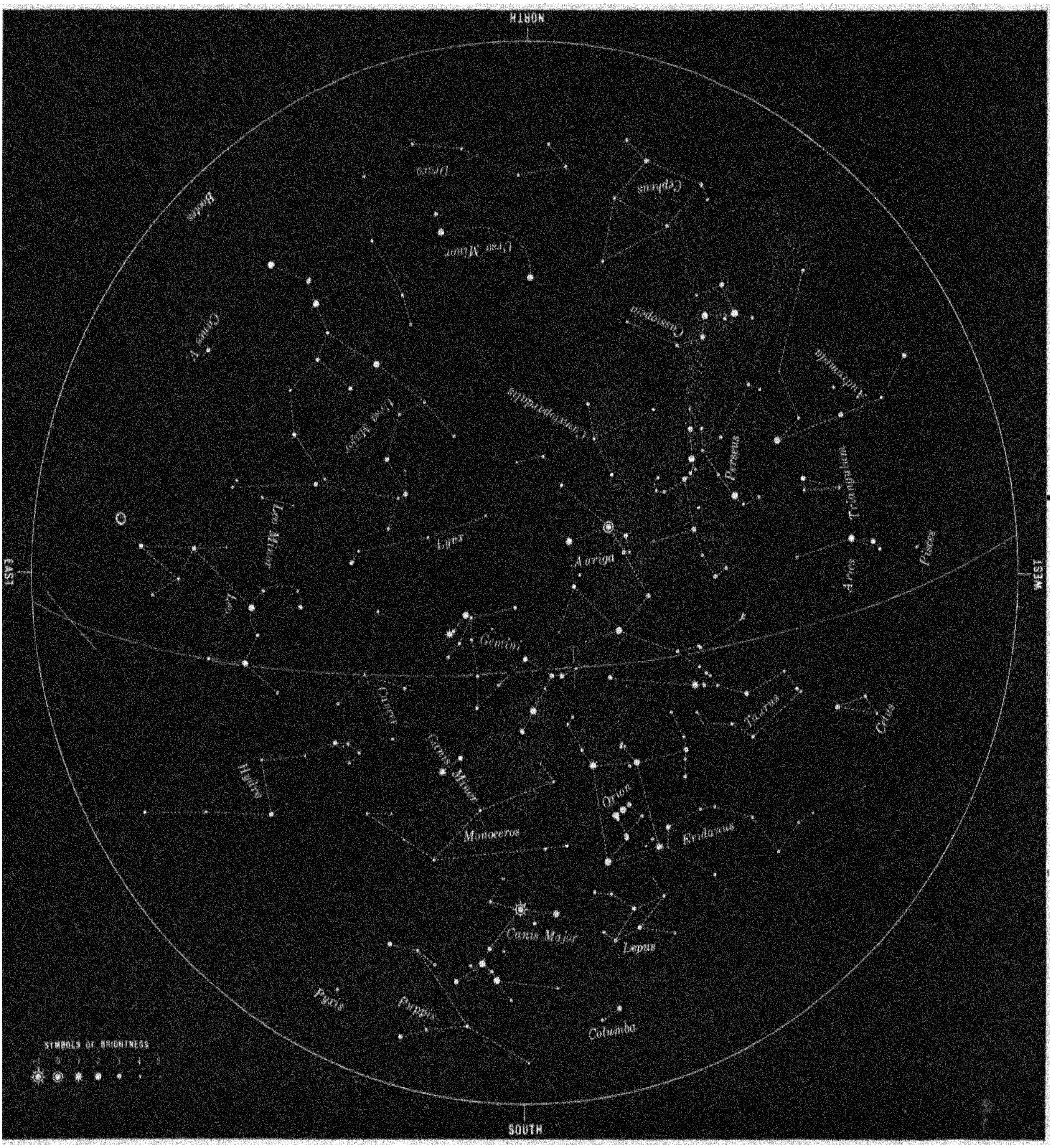
Auriga lies nearly overhead. Its most brilliant star, Capella, is easily found. It is much brighter than any star near it and vies with Vega, Arcturus, and Rigel for the honor of being the second brightest star ever visible in latitude 40 degrees. One naturally associates one of the stars of Taurus (Beta Tauri) with four of the brighter stars in Auriga to form an approximately regular pentagon (five-sided figure). This pentagon is shown on the chart. *Capella* means "little she-goat." The three stars near it are known as the "kids." The one nearest to Capella is Epsilon Aurigæ, a star the brightness of which varies from magnitude 3.4 to 4.1 with a period of 9,900 days, or over 27 years. This is the longest period known for a variable. It is an eclipsing variable. It decreases in brightness for 180 days, remains at the minimum 340 days, then returns to the original brightness in 180 days. One of the eclipses extends from June 1, 1928 to May 2, 1930.

CAMELOPARDALIS

This is a circumpolar constellation. It is discussed on page 19.

CHART 2

FEBRUARY



For use

February 15 from 8 to 10 p. m.

February 1, 9–11 p. m. **February 28, 7–9 p. m.**

For a later hour use Chart 3

For an earlier hour use Chart 1

See page 7

CHART 2
FEBRUARY

The following are the stars brighter than magnitude 1.5 shown on the chart:

SIRIUS in Canis Major	BETELGEUSE in Orion (upper star)
CAPELLA in Auriga	ALDEBARAN in Taurus
RIGEL in Orion (lower star)	POLLUX in Gemini
PROCYON in Canis Minor	REGULUS in Leo (near ecliptic)

GEMINI

Gemini is usually located by means of the brightest two stars of the constellation, Castor and Pollux. These bright stars are not far apart and are of approximately equal brightness. Pollux is the brighter one. Other stars of the constellation form a good Z, as shown on the chart. Below this Z are four stars, in a line which is nearly parallel to the bottom line of the Z. The arrangement of the stars is thus easily described.

Gemini means "twins." The names of the twins Castor and Pollux have been given to the bright stars, also. Telescopes show that Castor is a beautiful double star. Spectroscopes show that each of these two stars is double, that is, that there are really four stars in what appears as one to the naked eye. The middle star in the bottom line of the Z is Zeta Geminorum, well known as a typical variable star. Its magnitude varies regularly from 3.7 to 4.3 and back in 10.15 days. The summer solstice, that is, the point of the ecliptic at which the sun is on June 21, when farthest north, is in this constellation and is marked. The star One Geminorum is quite close to it. The star east of the solstice is Eta Geminorum, which varies irregularly between magnitudes 3.2 and 4.2 in an average period of 232 days.

ORION

Orion is unquestionably the finest of the constellations. It can be located most readily by means of the three bright stars lying nearly in a straight line in the middle of the constellation. They represent the belt of the giant hunter, Orion, and are usually referred to as the "Belt of Orion." They are also known as the "Yardstick" from the fact that the line is 3 degrees long. To some, they form the bottom of a dipper as indicated on the chart. The belt is surrounded by four bright stars which form a crude rectangle. Above the rectangle on the eastern side are the stars forming Orion's Club. The stream of five stars on the western side form the "lion's skin" which he carries. The lowest of the three close together above the rectangle is moving away from us at the rate of 61.2 miles a second. The two stars where the handle joins the bowl of the dipper mentioned above are in the Sword of Orion. There is another fainter star above them not shown. The middle one of the three is in the midst of the great nebula in Orion. The nebula gives the star a slightly cloudy appearance to the naked eye.

The brightest star of the constellation is Rigel, at the lower right-hand corner. It is very far away and intrinsically one of the most brilliant stars known. Diagonally opposite, at the upper left-hand corner, is Betelgeuse. It is a red star which is slightly variable. It was the first star to have its diameter measured with an interferometer. Its diameter has been found to be variable, ranging between 185,000,000 miles and 256,000,000 miles, that is, between 214 and 296 times the diameter of the sun. The larger value corresponds to a volume 26,000,000 times that of the sun and 34,000,000,000,000 times that of the earth.

Twenty-five stars in Orion are shown, which is a larger number than in any other constellation except Taurus, which has twenty-nine shown. Many of the stars of Orion but few of Taurus are bright. Orion and the neighboring constellations constitute by far the finest section of the whole sky.

LEPUS

Lepus lies just below Orion. It is easily located after Orion is known. Four of its most conspicuous stars form a neat diamond. The star east of this diamond is Delta Leporis, which is moving away from us at the rate of 61.6 miles a second. This is the greatest velocity for any star on these charts. The greatest velocity with which any star is known to be moving away from us is 211 miles a second.

COLUMBA

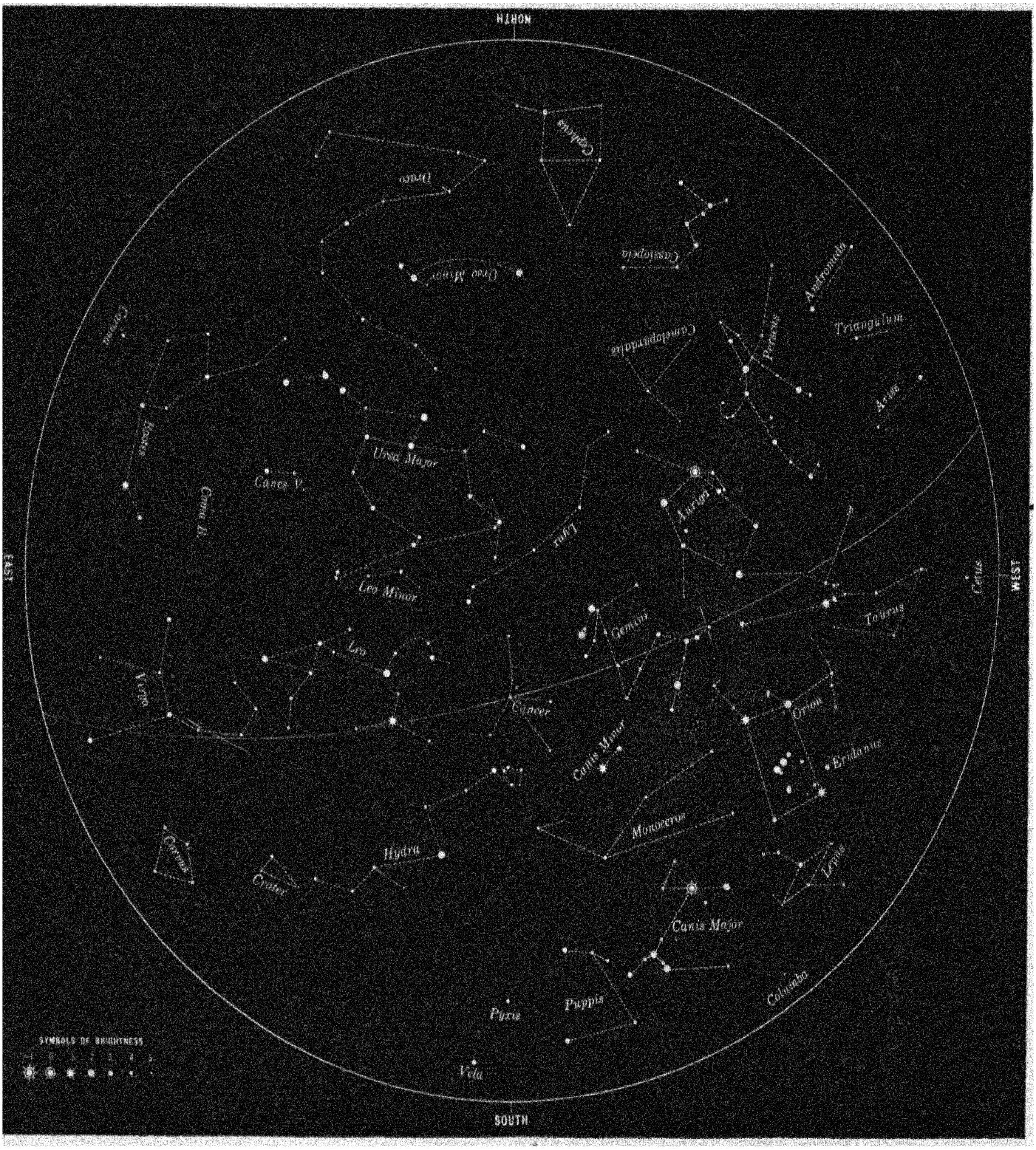
Columba is below Lepus and too far south to be seen well here, although the whole constellation is above the horizon. Only two stars appear on the chart. Cælum is west of Columba and entirely above the horizon, but it contains no stars bright enough to be shown.

CANIS MAJOR

This constellation contains Sirius, the brightest of all the stars. Sirius is 1.7 magnitudes brighter than any other star ever visible here. This star is thus very easy to find. South of Sirius are three stars in a triangle with nearly equal sides. Three stars with Sirius form a rough rectangle. Sirius, 8.8 light years away, is one of the nearest of the stars. No conspicuous star visible here is nearer. It gives out twenty-eight times as much light as the sun. Sirius is the "Dog Star," which gives its name to the dog days in summer, a period about the time when it is too close to the sun to be seen. They are usually considered as beginning July 3 and continuing 40 days, until August 11. The line of the belt of Orion points nearly to Sirius. The uppermost star shown is moving away from us at the rate of 60.7 miles a second.

CHART 3

MARCH



For use

March 15 from 8 to 10 p. m.

March 1, 9–11 p. m. **March 31, 7–9 p. m.**

For a later hour use Chart 4

For an earlier hour use Chart 2

See page 7

CHART 3

MARCH

The following are the stars brighter than magnitude 1.5 shown on the chart:

SIRIUS in Canis Major	BETELGEUSE in Orion (upper star)
CAPELLA in Auriga	ALDEBARAN in Taurus
ARCTURUS in Boötes	POLLUX in Gemini
RIGEL in Orion (lower star)	SPICA in Virgo (nearest to horizon)
PROCYON in Canis Minor	REGULUS in Leo

CANCER

Cancer is the faintest of the constellations of the zodiac. Its importance is due chiefly to the fact that it is in the zodiac. As it lies between the constellations Gemini and Leo, each of which is easily located, it is best to be sure of those constellations before looking for Cancer. The chart shows six stars in Cancer, the brightest of which is of magnitude 3.8. One of the stars, Delta Cancri, lies almost exactly on the ecliptic. Four lines, like the leg and toes of a fowl (crow's foot) radiate from this star. Just above Delta Cancri is the star Gamma Cancri, which is shown on the chart, although it is only of magnitude 4.7, because there is a hazy spot between these two stars in the position marked (+) on the chart. This hazy spot is visible to the naked eye under good conditions. It is called **"Præsepe"** (Pre-sē′-pē). Opera glasses or telescopes show that the spot is produced by a considerable number of stars clustered there just a little too faint to be seen separately with the naked eye. This cluster is known also as the "Beehive." The star west of Præsepe, also near the ecliptic, is Zeta Cancri, which in large telescopes appears as a very interesting system of three stars. Just south of Cancer lies the group of stars which form the "head of Hydra."

CANIS MINOR

Only two stars in this constellation appear on the chart, but one, Procyon, is very bright, and the constellation is known chiefly because of that star. Procyon, Betelgeuse, and Sirius form a great equilateral triangle of bright stars. Procyon, at a distance of 10.5 light years, is fourth in order of distance of the stars shown on these charts. Its brightness is due chiefly to its nearness, for it has the least luminosity of any star in Table IV, page 12. It gives out six times as much light as the sun. Procyon is a double star; the companion, which is of magnitude 13.0, has the smallest luminosity known, namely 0.00006. The sun emits 17,400 times as much light as this star. The name Procyon is derived from two Greek words, meaning "before" and "dog," thus indicating that it is the star which precedes the Dog Star, Sirius. The rising of the latter with the sun marks the time at which the river Nile overflows its banks, a very important event in Egypt. These two stars are then like watchdogs warning of its approach.

MONOCEROS

This is a faint constellation east of Orion in the midst of bright ones. A circle can be drawn on Chart 2 with a radius of 1½ inches and center near the star in Monoceros, which is nearest to Betelgeuse, which contains fifteen stars brighter than magnitude 2.0. There are but forty such stars in the whole heavens, and ten of these never come above the horizon here. The circle includes about a fourteenth of the sky and less than an eleventh of the parts seen here. Since it contains an equal number of stars, with the other parts ten times as large, it is ten times as rich in such bright stars as are the other parts of the sky which we see. Yet Monoceros, in the midst of this circle, has no star brighter than magnitude 3.9.

PUPPIS, PYXIS, VELA

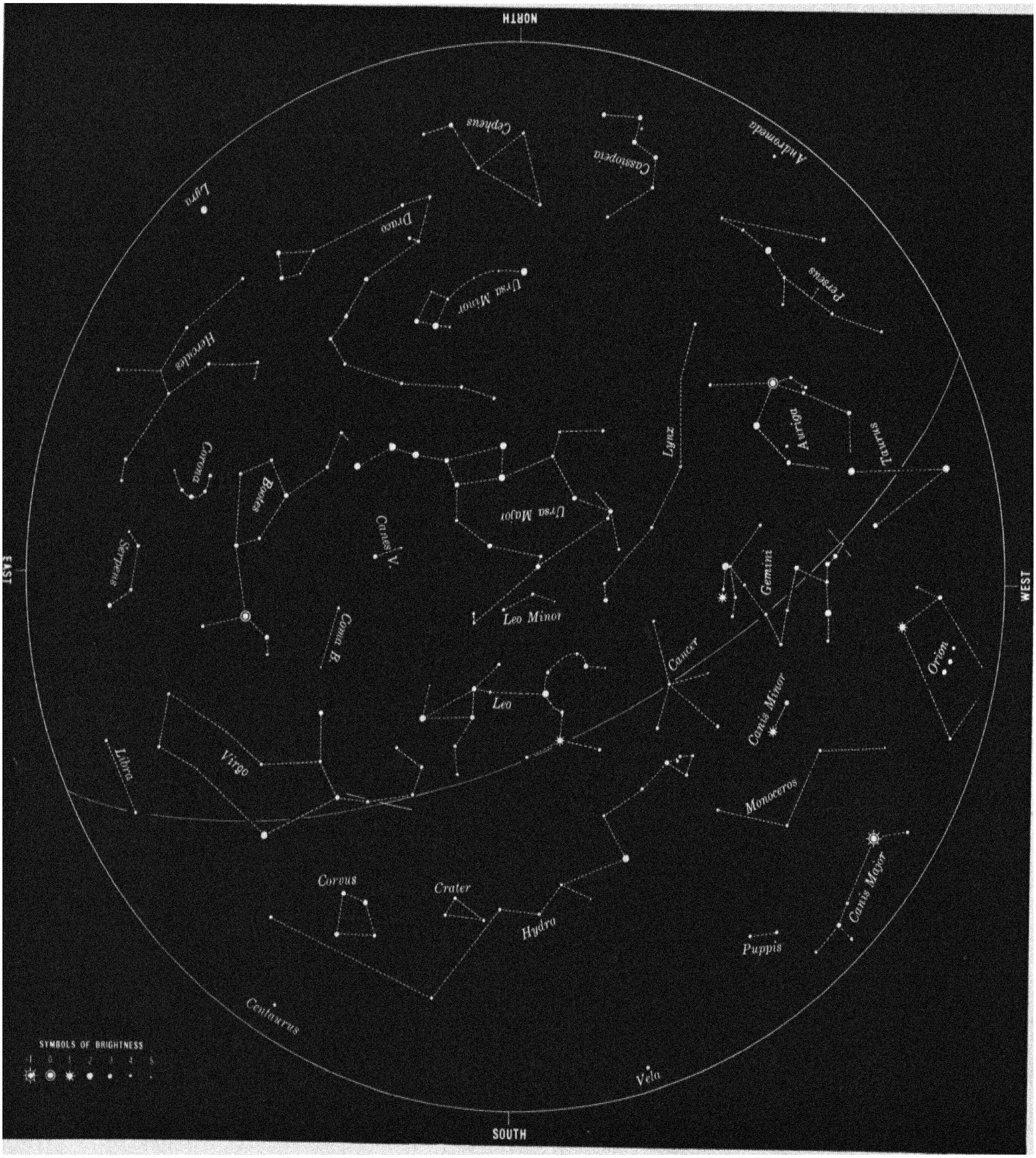
The large constellation formerly called "Argo" was divided into four parts called "Carina," "Puppis," "Pyxis," and "Vela." Pyxis is entirely above the horizon at times, and parts of Puppis and Vela. All are too far south, however, to be seen well. Five stars of Puppis, one of Pyxis, and one of Vela appear on the chart. Two other stars of Puppis appear on the February chart. Canopus, which is Alpha Carinæ, is the second-brightest star in the heavens. It is just below the south point of the February chart. It rises above the horizon south of 38 degrees latitude but not in 40 degrees.

LYNX

Lynx is a very faint constellation north of Gemini. Six stars appear on the chart, arranged in a stream. Like any faint constellation, it is learned most easily after the brighter constellations surrounding it have been learned.

CHART 4

APRIL



FOR USE

April 15 from 8 to 10 p. m.

April 1, 9-11 p. m. **April 30, 7-9 p. m.**

For a later hour use Chart 5

For an earlier hour use Chart 3

See page 7

CHART 4

APRIL

The following are the stars brighter than magnitude 1.5 shown on the chart:

SIRIUS in Canis Major	BETELGEUSE in Orion
VEGA in Lyra	ALDEBARAN in Taurus (nearest to horizon)
CAPELLA in Auriga	POLLUX in Gemini
ARCTURUS in Boötes	SPICA in Virgo
PROCYON in Canis Minor	REGULUS in Leo

LEO

Leo is usually identified by the "Sickle in Leo." This name is applied to the group of stars in the western part of the constellation, which are so situated that they suggest the form of a sickle or of a reversed question mark, as shown on the chart. This Sickle and the right-angled triangle of stars east of it comprise the brighter stars of the constellation. The brightest star of the constellation is Regulus, which is at the end of the handle of the Sickle. It is just north of the ecliptic. It is one of the four Royal Stars mentioned in connection with Taurus (p. 21). The other bright star in the Sickle is Gamma Leonis, a well-known double star. This star is almost exactly 9 degrees from the ecliptic, and therefore it is on the northern boundary of the zodiac. No planet is ever at a greater distance from the ecliptic. A line through this star and Regulus leads to the brightest star in Hydra. The brightest star in the triangle in Leo, the one farthest east, is Beta Leonis, which is also called "Denebola."

CRATER

The constellation Sextans lies in the empty region south of Regulus. Its brightest star is of magnitude 5.2; hence, no stars are shown on the chart. Crater appears as a triangle of three faint stars just above Hydra. South of Hydra and a little to the west of Crater lies Antlia. The whole constellation is above the horizon, but as it lies near the horizon and its brightest star is of magnitude 4.4, no star is bright enough to be shown on the chart.

LEO MINOR

Leo Minor lies just north of Leo. Only three rather faint stars appear on the chart.

URSA MAJOR

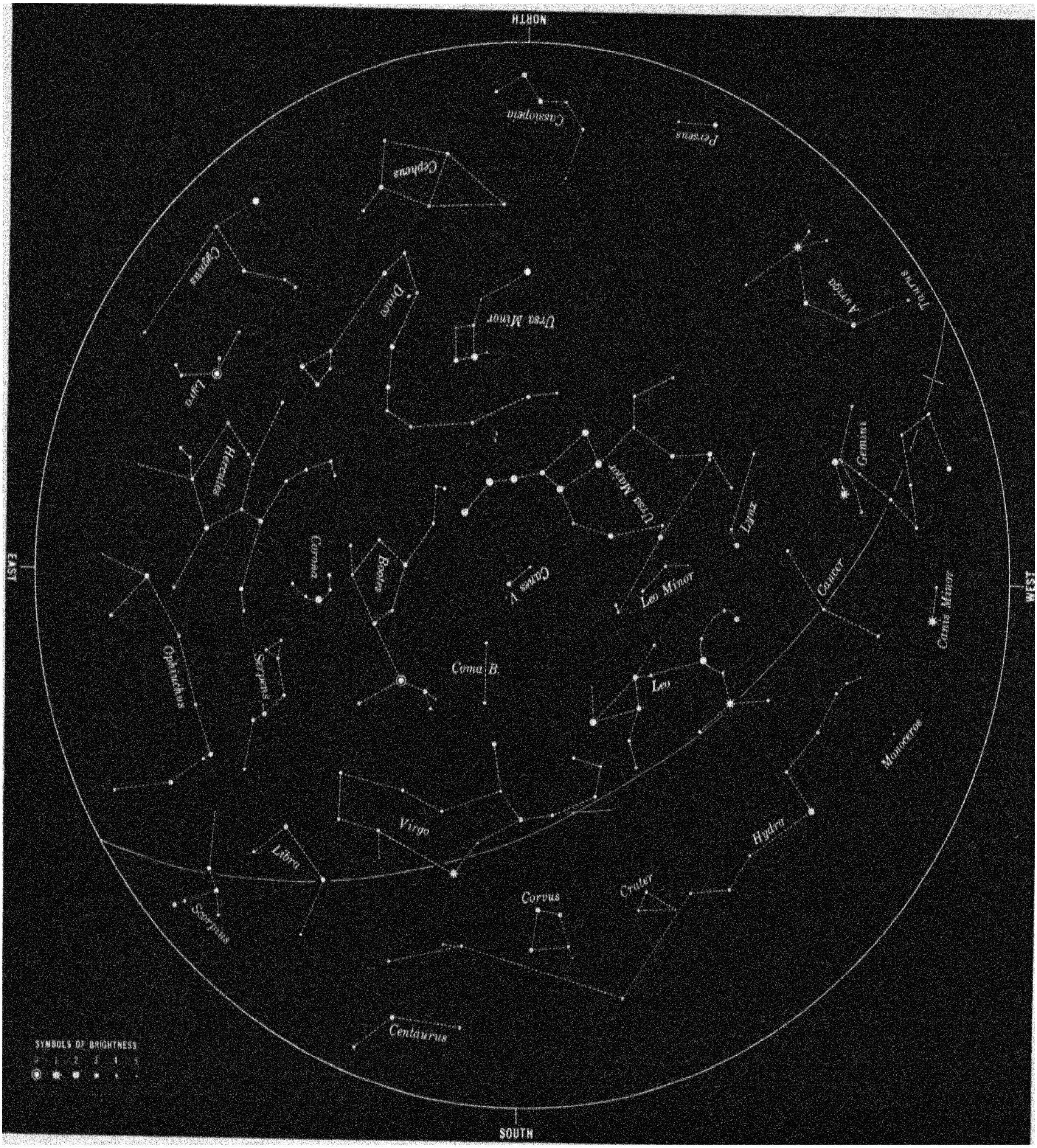
In the northern hemisphere, this is probably the most widely known of all constellations. A part of the constellation is commonly known in the United States as the "Big Dipper," because seven of the brighter stars are situated in a manner which suggests the outline of a dipper. There are many other designations for the same group, such as "Charles's Wain" (wagon), the "Plough," and the "Butcher's Cleaver." The constellation, however, is very much larger than the Dipper and includes many other stars. Fifteen others are shown on the chart. To the west of the bowl of the Dipper lies a group of stars situated roughly in a semicircle, with a pair of stars near each other at its southern end. Starting with the stars at the bottom of the bowl of the Dipper, we find another group of stars arranged in almost identically the same manner and likewise ending with a pair of stars. The fact that each of these groups of stars is almost exactly the duplicate of the other is a remarkable coincidence. On the southern boundary of the constellation are three very similar pairs of stars, including those just mentioned, which lie nearly in a straight line. The manner in which Polaris, the North Star, can be found from the pointers in Ursa Major has already been explained on page 18.

The star at the end of the handle of the Dipper is called "Alkaid" or sometimes "Benetnasch." The one next to it is Mizar. Close beside Mizar is a fourth-magnitude star, called "Alcor." This has always been an interesting star because of its position. Alcor is not difficult to see under good conditions, but it has been said to be a test of eyesight. This gave rise to the proverbial expression, "He sees Alcor but not the full moon," referring to one who sees little details while missing basic principles. Mizar is interesting historically, as it was the first star to be discovered and mentioned as a double star. It was also the first double star satisfactorily photographed. Its brighter component was the first star discovered with a spectroscope to be double. Later, the other component and Alcor also were discovered in the same manner to be double. Alcor is a little over 11′ away from Mizar. The third star in the handle of the dipper is Alioth. The pointers are called "Dubhe" and "Merak," the former being the closer to the pole.

It is a very interesting fact that all of the stars of the Big Dipper, except Alkaid and Dubhe, are found to be moving together through space. A considerable number of other stars, widely scattered, have the same motion through space. One of these is Sirius in Canis Major. It is the nearest of the group. Beta Aurigæ (the bright star southeast of Capella) is the most remote at a distance of 135 light years. Together, the stars form a flat cluster. They range from 8 to 400 times as bright as the sun.

CHART 5

MAY



FOR USE

May 15 from 8 to 10 p. m.

May 1, 9–11 p. m. **May 31, 7–9 p. m.**

For a later hour use Chart 6

For an earlier hour use Chart 4

See page 7

CHART 5

MAY

The following are the stars brighter than magnitude 1.5 shown on the chart:

VEGA in Lyra	SPICA in Virgo
CAPELLA in Auriga	ANTARES in Scorpius (nearest to horizon)
ARCTURUS in Boötes	DENEB in Cygnus
PROCYON in Canis Minor	REGULUS in Leo
POLLUX in Gemini	

VIRGO

The stars of Virgo are arranged in a manner not easily described. Most of them are included in two streams, which run in nearly parallel courses. If we think of the handle of the Big Dipper in Ursa Major as an arc of a circle and extend this arc southward, we are led to the bright star Arcturus in Boötes, and, continuing on the arc, we are led to Spica, the brightest star in Virgo. About 45 degrees of the ecliptic lie within Virgo, more than in any other constellation. For the "Diamond of Virgo," see below. Arcturus, Spica, and Antares form a large, right-angled triangle.

CORVUS

Southwest of Spica in Virgo is the rather conspicuous quadrilateral of stars in Corvus, easily identified. One other faint star is shown.

HYDRA

This constellation consists of a long stream of stars bearing some suggestion of the water snake from which it derives its name. The constellation extends 105 degrees in the east-west direction and from 10 degrees north of the celestial equator to 35 degrees south of it. No other constellation contains stars so widely separated. The star out of the main stream at the eastern end is R Hydræ, a star which varies from magnitude 4.0 to 9.8 and back in 425 days. As it is usually invisible to the naked eye, it is shown on this chart only. This is the only chart on which this unusual constellation appears in its full length. The head of Hydra may be seen best on Chart 3.

COMA BERENICES

Coma Berenices is a minor constellation north of Virgo and west of Arcturus in Boötes. Only two stars are bright enough to be shown on the chart. There are many stars, however, in the constellation, which are just bright enough to be seen faintly under good conditions with the naked eye. There is a cluster of such stars west of the two shown, about midway between Denebola, the easternmost star shown in Leo, and the stars shown in Canes Venatici. The north pole of the Milky Way lies in this constellation. It is well known that almost all kinds of celestial objects show a marked relationship to the Milky Way in their distribution, being most numerous near the Milky Way and falling off in number as its poles are approached. The reverse is true of the spiral nebulæ as they are most numerous near the poles of the Milky Way. The western part of Virgo is particularly full of such nebulæ.

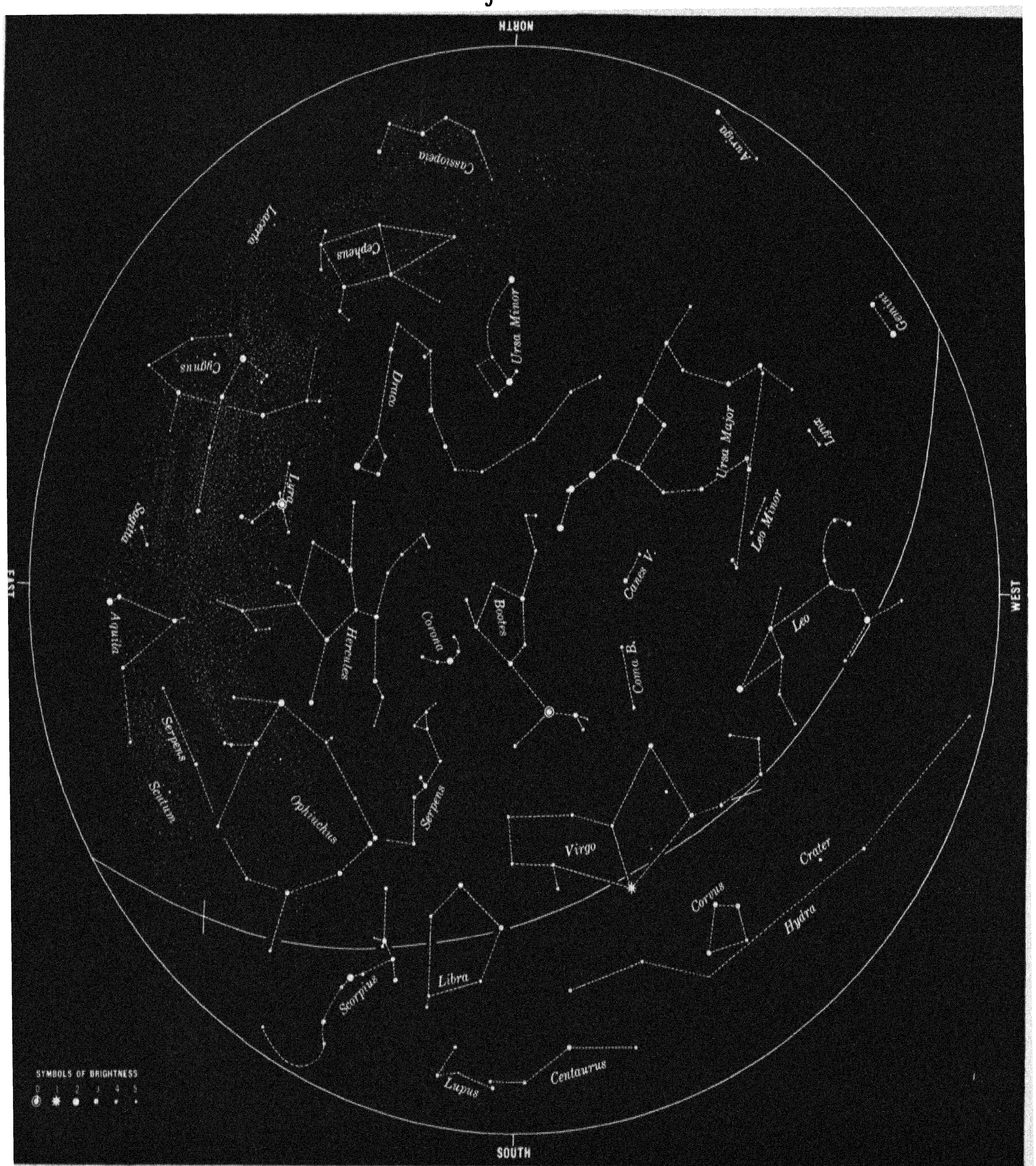
CANES VENATICI

This is another minor constellation. It is just at the zenith on this chart. Only two stars are shown. The brighter one is sometimes called "Cor Caroli" (Kor Ka'rōl-ī). This star joined with Arcturus in Boötes and with Denebola in Leo and these two in turn joined with Spica in Virgo form the so-called "Diamond of Virgo." There is a pretty well-marked diamond within the constellation itself, however, for which the title seems more appropriate. The stars at its corners are the northernmost star of Virgo, Spica, the star about a third of the way from Spica toward Arcturus, and the one a little less than halfway toward Denebola. The figure stands out better in the sky than from the chart. This diamond is shown on Chart 6. The westernmost star of the diamond is Gamma Virginis, a well-known double star.

The constellation Canes Venatici is well known as the one in which the "whirlpool nebula," the finest of the spiral nebulæ, is located. The nebula is about quarter way from the star at the end of the handle of the Big Dipper toward Cor Caroli. It cannot be seen with the naked eye. There is also a fine globular star cluster in this constellation.

CHART 6

JUNE



For use

June 15 from 8 to 10 p. m.

June 1, 9–11 p. m. **June 30, 7–9 p. m.**

For a later hour use Chart 7

For an earlier hour use Chart 5

See page 7

CHART 6

JUNE

The following are the stars brighter than magnitude 1.5 shown on the chart:

VEGA in Lyra	SPICA in Virgo
CAPELLA in Auriga	ANTARES in Scorpius
ARCTURUS in Boötes	DENEB in Cygnus
ALTAIR in Aquila	REGULUS in Leo (near ecliptic)
POLLUX in Gemini	

LIBRA

The stars of Libra form a fairly regular pentagon. Those on the southern side are included in Scorpius by some. The uppermost star, Beta Libræ, is the only naked-eye star which has a greenish color. An opera glass shows that it is a double star. Alpha Libræ is the star just north of the ecliptic. Recognition of this fact helps in tracing the position of the ecliptic among the stars.

LUPUS

Lupus lies just south of Libra. A large part of the constellation is above the horizon, but it is too far south to appear well.

CENTAURUS

Centaurus is west of Lupus. A very important part of this constellation lies below the horizon and is never seen here. The upper star at the eastern side is in Centaurus and the lower one, in Lupus.

BOÖTES

Many of the stars in Boötes lie in a stream which starts at the end of the handle of the Big Dipper and forms an extension of it, leading to the brilliant star, Arcturus. Some of the stars in Boötes form a pentagon, which has been compared to a kite. The name *Boötes* has come down to us from very ancient times. It is mentioned by Homer in the "Odyssey."

Arcturus is one of the brightest stars in the whole heavens. Sirius is the brightest of all and is followed by two others which are too far south ever to be seen here. Vega, Capella, and Arcturus follow but are so nearly alike in brightness that some find one and some another to be the brightest of the three. An accurate comparison is difficult, as the three are of different colors. Vega has a blue tinge, Capella, a yellow tinge, and Arcturus, a red tinge. Arcturus is 41 light years distant and gives out 112 times as much light as the sun. It is one of the largest stars. Its diameter is 25,500,000 miles, which is 29.5 times that of the sun. Its volume is 26,000 times that of the sun. In 1718, Halley announced that Arcturus, Sirius, and Procyon had changed their positions since ancient times. These were the first stars found to be moving and not absolutely fixed. With the exception of Alpha Centauri, not visible here, no star as bright as the fourth magnitude changes its position among the stars as rapidly as does Arcturus. Nevertheless, about 1,570 years are required for a change of 1 degree. The distance between Arcturus and the star on the chart just west of it is about 4 degrees. Arcturus is moving through space with a velocity of 77 miles a second. The velocity of the sun in space is 12 miles a second. While the velocity of Arcturus is large, many stars move with greater velocities. The greatest known velocity of a star through space is 625 miles a second. Arcturus is mentioned in Job 38:32, authorized version. The revised version changes the translation.

CORONA BOREALIS

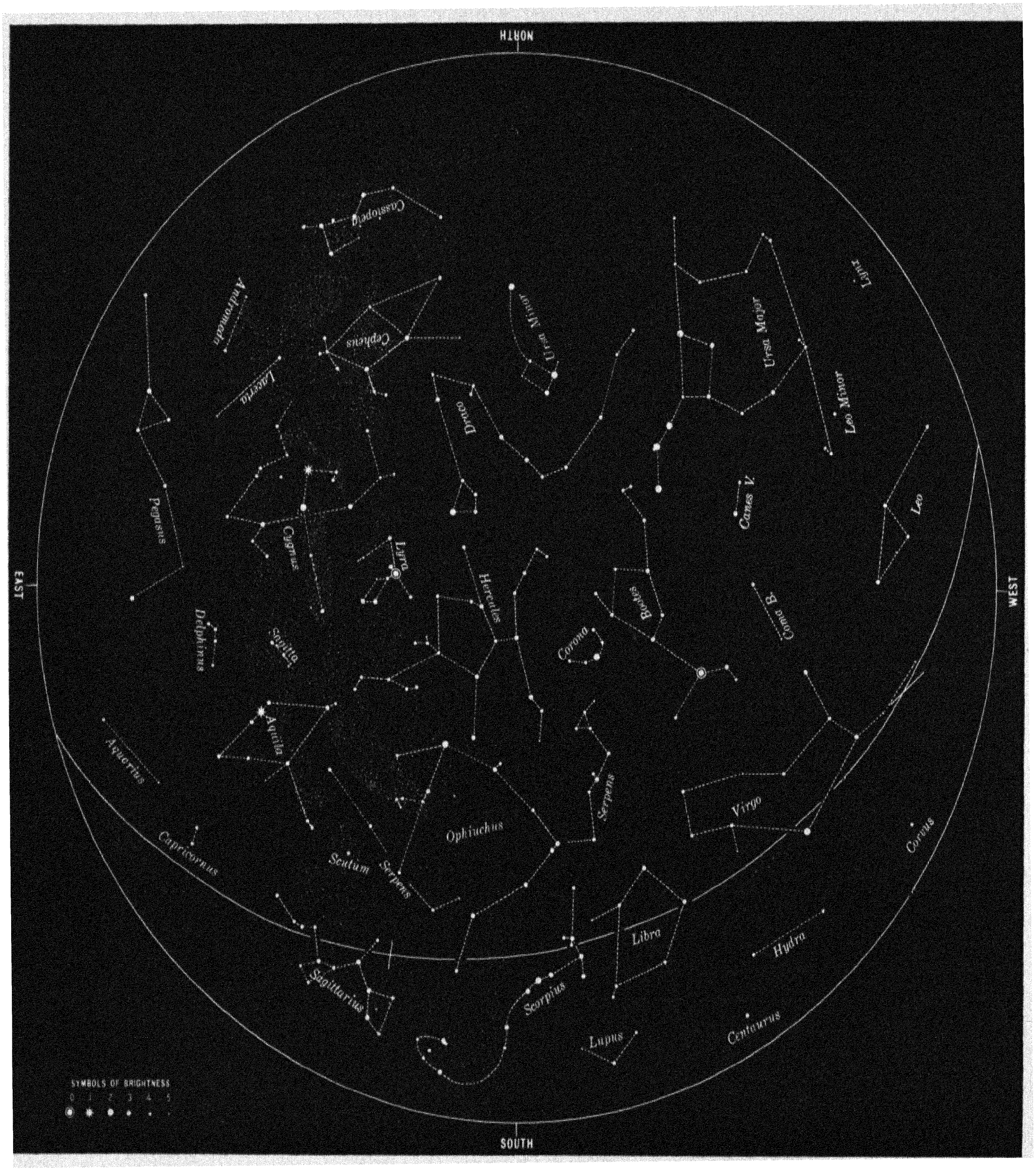
The principal stars of this constellation form a good semicircle. It is one of the few constellations for which the name seems appropriate. On the charts the name of this constellation is abbreviated to "Corona."

URSA MINOR

This constellation is in its best position on this chart. It is discussed as a circumpolar constellation on page 18.

CHART 7

JULY



FOR USE

July 15 from 8 to 10 p. m.

July 1, 9-11 p. m. July 31, 7-9 p. m.

For a later hour use Chart 8

For an earlier hour use Chart 6

See page 7

CHART 7

JULY

The following are the stars brighter than magnitude 1.5 shown on the chart:

VEGA in Lyra	SPICA in Virgo
ARCTURUS in Boötes	ANTARES in Scorpius
ALTAIR in Aquila	DENEB in Cygnus

SCORPIUS

Scorpius is probably the finest of the constellations of the zodiac. It is so far south that it is unfavorably situated for observation in this latitude. Its conspicuous features are three bright stars, which form the advance guard of the constellation and the long, curved stream of stars which follows them. This sweeping tail is a beautiful sight when the southern sky is clear. Some compare the constellation to a kite with its tail.

The brightest star of the constellation is Antares. The name (*anti-Ares*) means the "Rival of Mars" (Ares). Both the planet and the star are red in color. This probably suggested a rivalry when the two were near together. Antares is one of the largest stars known. Using 125 light years as the distance (Table IV) the diameter is 142,000,000 miles, which is 165 times that of the sun.

Although Scorpius is a constellation of the zodiac and a very large one, too, only a small part of the ecliptic lies within its bounds, less, in fact, than in any other of the twelve. Much more of the ecliptic lies within Ophiuchus adjacent, which is not one of the twelve zodiacal constellations, than in Scorpius.

OPHIUCHUS AND SERPENS

These constellations are inseparably connected. The man, Ophiuchus (Greek for "serpent-holder"), holds Serpens (the serpent) in his hands. Ophiuchus is sometimes called "Serpentarius" (Latin for "serpent-holder"). Serpens is separated into two parts, one to the east and one to the west of Ophiuchus. The serpent crosses the body of Ophiuchus. This is the only constellation with separated parts. The two stars of Ophiuchus, which are of nearly the same brightness near each other on the western side of the constellation, attract the attention and make a good starting point for tracing out each constellation. They mark one of the hands of Ophiuchus. The small triangle in the head of Serpens lies south of Corona. These three stars with two others, one too faint to be shown, form an X. One of the brighter stars of Ophiuchus lies south of the ecliptic. No other constellation, which is not one of the twelve constellations of the zodiac, is crossed by the ecliptic, although parts of others are in the zodiac. Figure 1, page 9, shows a section of the Milky Way just north of this star.

HERCULES

There are no very bright stars or striking groups in this constellation, so that it is not very easy to identify. Six of the brighter stars are arranged in the form of a crude H or more nearly in the form of an inverted K, thus, ꓘ. The eastern side of the ꓘ forms two sides of a pentagon. The upper and lower halves of the ꓘ resemble the wings of a flying butterfly. Hercules lies between Corona, described on page 31 and Lyra, with its brilliant star Vega.

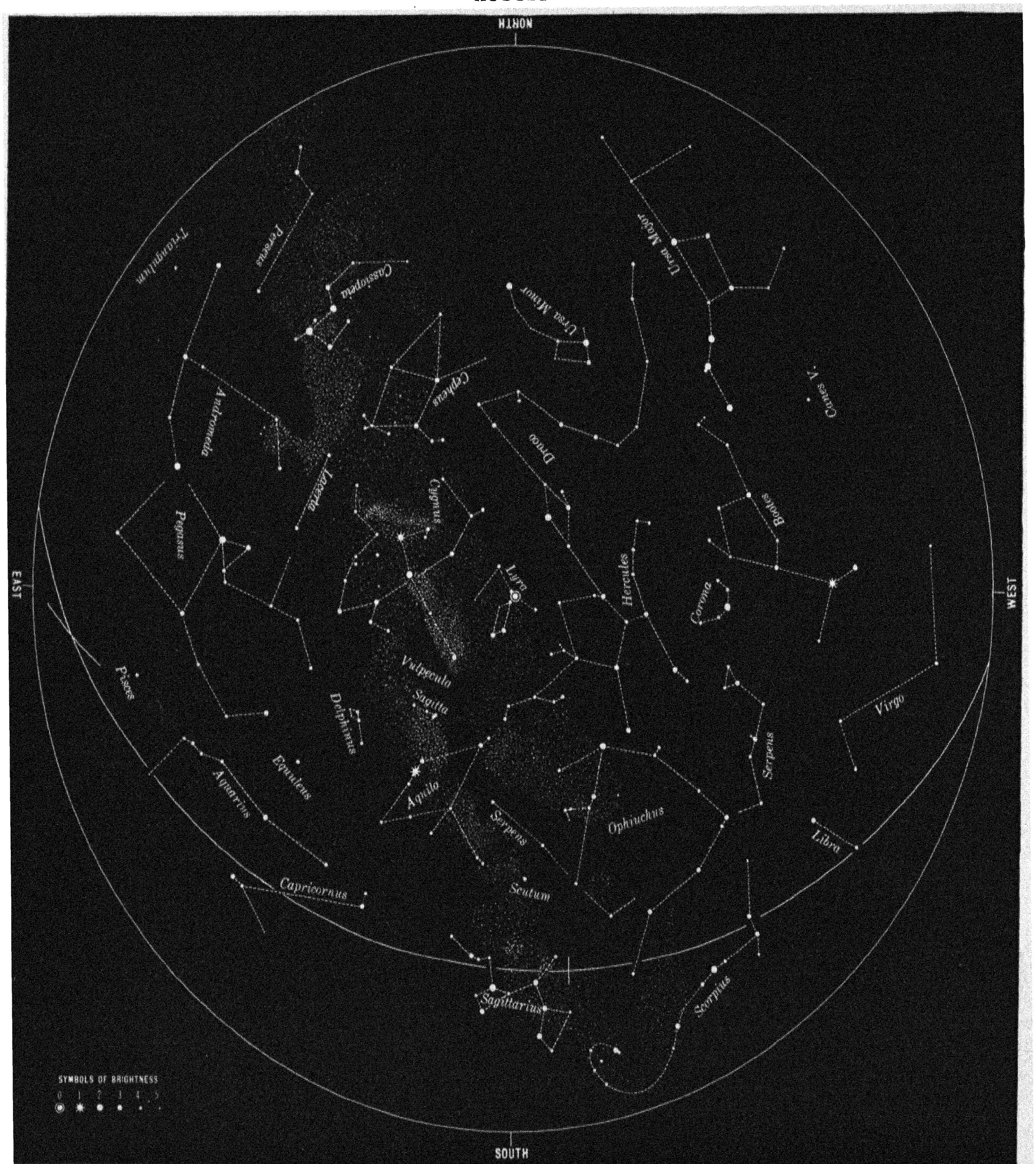
The star nearest to Ophiuchus is Alpha Herculis, a colored double star. It is a red star, the brightness of which varies irregularly from magnitude 3.1 to 3.9. One of the finest globular star clusters is located in Hercules. It is commonly called the "great star cluster in Hercules." It is just visible to the naked eye under fine conditions as a hazy spot. It lies between the two stars which form the upper right side of the ꓘ, about a third of the way from the upper star. Its distance is 36,000 light years.

DRACO

Draco is in its best position on this chart. It is discussed among the circumpolar constellations on page 19.

CHART 8

AUGUST



FOR USE

August 15 from 8 to 10 p. m.

August 1, 9–11 p. m. **August 31, 7–9 p. m.**

For a later hour use Chart 9

For an earlier hour use Chart 7

See page 7

CHART 8

AUGUST

The following are the stars brighter than magnitude 1.5 shown on the chart:

VEGA in Lyra
ARCTURUS in Boötes
ALTAIR in Aquila
ANTARES in Scorpius
DENEB in Cygnus

SAGITTARIUS

Sagittarius is the southernmost constellation of the zodiac. There are two good ways of joining the stars, one of which is given on this and the other on the next chart. This chart shows the so-called "little milk dipper in Sagittarius." It is an inverted dipper, with four stars to form the bowl and one to form the handle, in the eastern part of the constellation. The arrangement on the next chart is similar to that found in Canis Major. The Milky Way in Sagittarius is very bright and complicated. Some of the great star clouds in the Milky Way are found there. Many of the globular star clusters lie in this direction. The southernmost point of the ecliptic, the winter solstice, is in Sagittarius and marked on the chart. The sun is at this point about Dec. 22.

The constellation Corona Australis lies just below Sagittarius. It is entirely above the horizon but contains no stars bright enough to be shown on the chart. It is not likely to be confused with Corona Borealis, which has been marked simply "Corona" on the charts.

SCUTUM

Above Sagittarius lies Scutum. Only one star appears. The constellation is sometimes given the more complete name, Scutum Sobieskii.

AQUILA

The most conspicuous feature of the constellation Aquila is the bright star Altair and two fainter stars on either side of it, the three lying in a straight line. The parallelogram shown on the chart includes most of the stars of the constellation. The star in the middle of the southern side of the parallelogram is the variable star Eta Aquilæ, a star the brightness of which varies from magnitude 3.7 to 4.5 and back in a period of 7.18 days. Altair is 16 light years away and is fifth in order of distance of the stars shown on these charts. The Milky Way runs through Aquila and is divided into two branches there.

LYRA

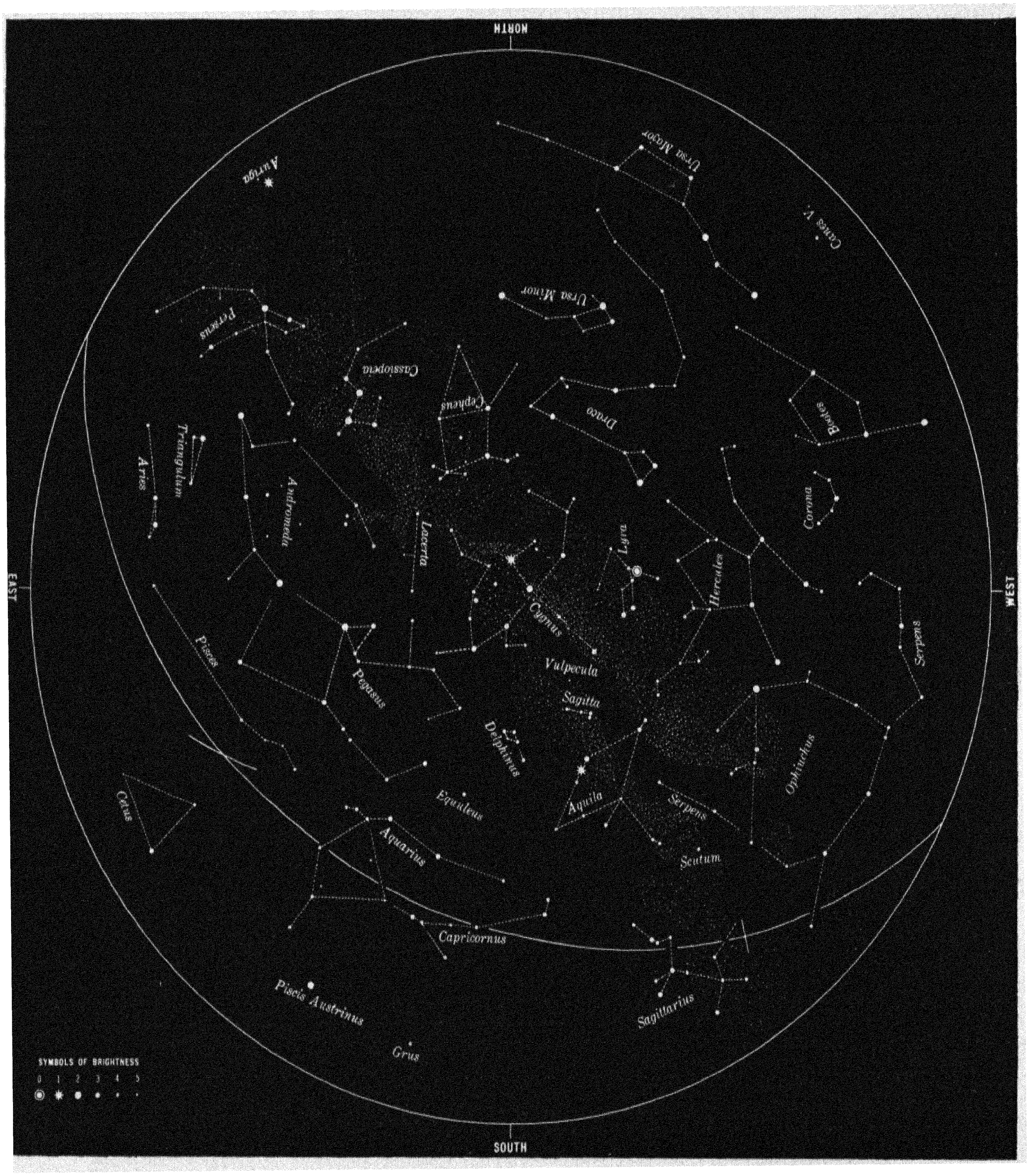
This small but important constellation is now at the zenith. Its brightest star, Vega, is the fourth star in the heavens in order of brightness and next to the brightest star ever seen here. Two much fainter stars form with Vega an equal-sided triangle, and the southern one of these two stars is at a corner of a good parallelogram. The northern star of the two is Epsilon Lyræ. It consists of two stars very close to each other. Those who have exceptional eyesight can see the stars separately with the naked eye. Telescopes show that each of the two is a double star, that is, that there are four stars in what appears to the naked eye as a single star. The star at the southwestern corner of the parallelogram is Beta Lyræ, a well-known variable star. Its magnitude varies from 3.4 to 4.1 and back regularly in a period of 12.9 days. Just east of it but not visible to the naked eye is the ring nebula in Lyra. The star nearest to Draco shown is R Lyræ, a star which varies irregularly from magnitude 4.0 to 4.7.

The sun is moving through space with a velocity of 12 miles a second, carrying the earth and all the other planets with it. The motion is nearly in the direction of the constellation Lyra. The velocity is sufficient to take us four times the distance from the earth to the sun in a year. As the earth moves around the sun and at the same time moves with the sun in space, its combined motion is spiral. If the motion of the sun were exactly in the direction of Vega and Vega itself did not move, we would not reach it for 475,000 years. Vega is 26 light years away and gives out fifty-one times as much light as the sun.

*

CHART 9

SEPTEMBER



FOR USE

September 15 from 8 to 10 p. m.

September 1, 9-11 p. m. **September 30, 7-9 p. m.**

For a later hour use Chart 10

For an earlier hour use Chart 8

See page 7

CHART 9

SEPTEMBER

The following are the stars brighter than magnitude 1.5 shown on the chart:

VEGA in Lyra	ALTAIR in Aquila
CAPELLA in Auriga	FOMALHAUT in Piscis Austrinus
ARCTURUS in Boötes	DENEB in Cygnus

CAPRICORNUS

Capricornus is neither a brilliant nor a well-defined constellation. Some of the stars form a V, which, if joined with one of the stars of Aquarius, makes a Y with the bottom toward the east, as shown on the chart. The westernmost star of Capricornus shown is Alpha Capricorni, which consists of two stars so close together that they can just be separated with the naked eye. It lies on a straight line through Vega and Altair. Next to Cancer and Pisces, Capricornus is the least conspicuous of the constellations of the zodiac.

Just south of Capricornus is Microscopium. The entire constellation is above the horizon, but it contains no stars which are bright enough to be shown on the chart.

EQUULEUS

Equuleus is one of the very small constellations. Only one star (Alpha Equulei) is shown on the chart. The next brightest star is Delta Equulei (magnitude 4.6), which has the shortest period of revolution known for any star actually seen to be double, namely 5.7 years.

DELPHINUS

Delphinus is easily identified by the diamond-shaped group of faint stars. This group is often called "Job's Coffin." No one knows the origin of this peculiar name.

SAGITTA

Four stars are shown in Sagitta. *Sagitta* means "arrow." The positions of the stars suggest an arrow with a feathered end. This is the smallest of the constellations.

VULPECULA

Vulpecula is another constellation in which only one star is shown. The dumb-bell nebula lies in this constellation.

CYGNUS

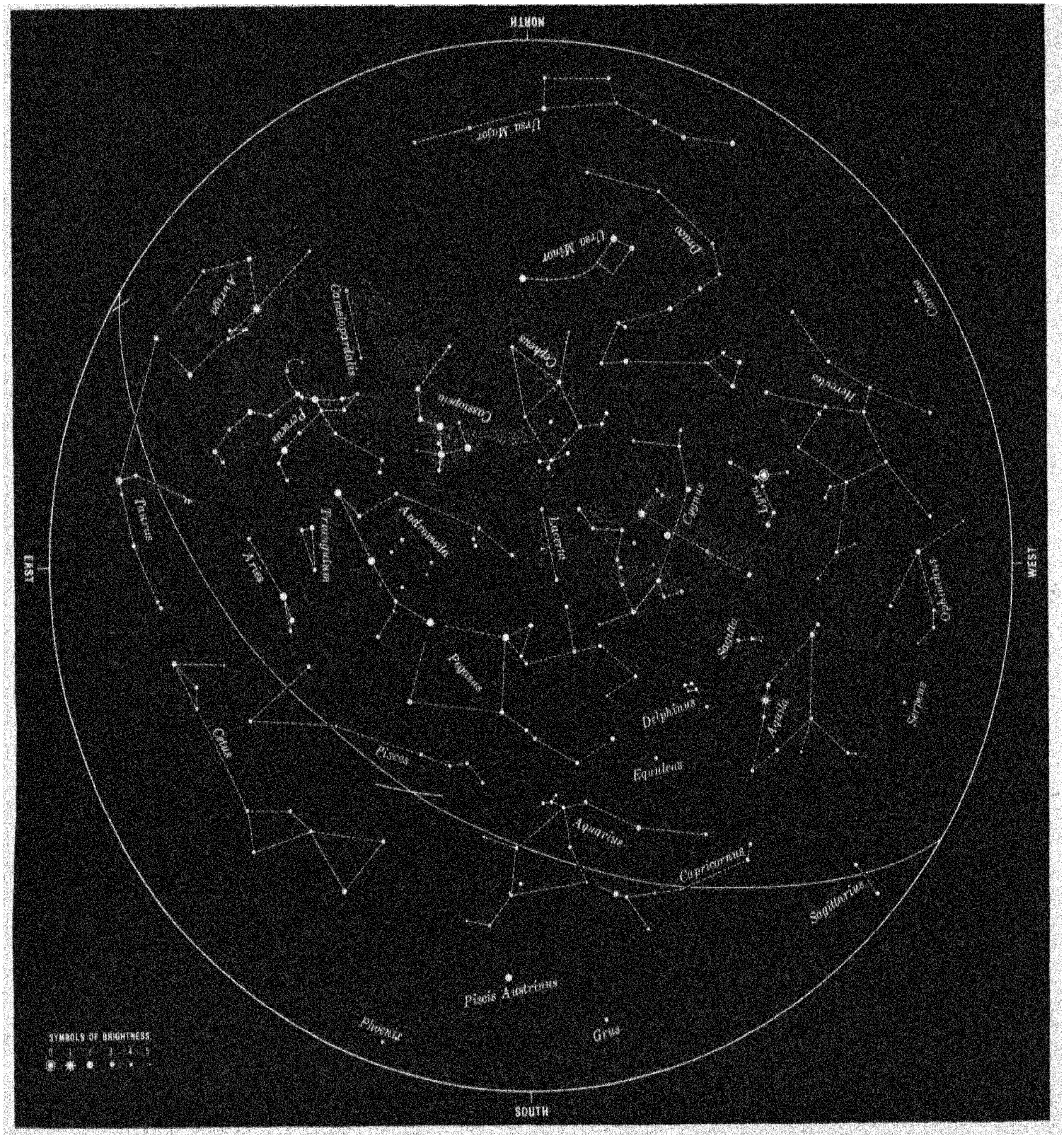
Cygnus is the only conspicuous constellation described in connection with this chart. The brightest star in any of the constellations described above is of magnitude 3.0. Cygnus is often called the "Northern Cross," because the brighter stars are arranged in the form of a cross, but the name means "swan." There is a constellation Crux, which means "cross," which cannot be seen in this latitude. This is usually called the "Southern Cross." Cygnus can easily be recognized from the resemblance to a cross or a dagger. The whole constellation lies in the Milky Way, with the long arm of the cross in the direction of its length. The brightest star in the constellation is Deneb, which is at the top of the cross. The star at the bottom of the cross is Beta Cygni, sometimes called "Albireo," which is a fine, colored, double star. The star next to this one is Chi Cygni, which varies from magnitude 4.0 to 13.5 and back in a period of 405 days. As it is usually not visible to the naked eye, it is shown on this chart only.

Attempts to determine the distance of Deneb have only shown that its distance is greater than can be determined with accuracy. Hence, as it is so bright to us, it must be a star of enormous intrinsic brilliance. Table IV, page 12, shows it to be 10,470 times as bright as the sun. Observations have demonstrated that Deneb's position among the stars does not change, so far as we can detect, even after a long period of observation. This is remarkable for a star of the first magnitude. The spectroscope shows that it is a double star and that it approaches us at the slow rate of 2.5 miles a second. The Milky Way is bright in Cygnus. Near Deneb is an open place in it called the "Northern Coalsack," the principal coalsack being near the Southern Cross. The Milky Way separates into two branches in Cygnus.

The star in the short arm of the cross west of the intersection is of magnitude 3.0, and the two north and west of this are each of magnitude 4.0. These stars may be taken as samples of stars of the third and of the fourth magnitudes.

CHART 10

OCTOBER



For use

October 15 from 8 to 10 p. m.

October 1, 9–11 p. m. **October 31, 7–9 p. m.**

For a later hour use Chart 11
For an earlier hour use Chart 9
See page 7

CHART 10

OCTOBER

The following are the stars brighter than magnitude 1.5 shown on the chart:

VEGA in Lyra	ALDEBARAN in Taurus
CAPELLA in Auriga	FOMALHAUT in Piscis Austrinus
ALTAIR in Aquila	DENEB in Cygnus

AQUARIUS

Aquarius is an irregular constellation of the zodiac and not easily described. One branch of it lies above Capricornus and extends nearly as far west as that constellation does. In the upper part of the constellation is a compact group of stars forming the "Y of Aquarius," so-called because the stars are arranged roughly in the form of that letter. *Aquarius* means the "water carrier." This group, the Y, is the water jar from which he is pouring water. One of the stars forming it has been placed on the chart, although it is below our limit of brightness.

PISCIS AUSTRINUS

Piscis Austrinus, or "Piscis Australis," as it is frequently called, lies just south of Aquarius. Only one star appears on the chart. This star, Fomalhaut, is the southernmost star of the first magnitude ever seen in this latitude. As it is brighter than any other star in its vicinity, it is easily found. It is nearly in the line of the western side of the great square in Pegasus (see below).

Very curiously Aquarius is pictured as pouring water into the mouth of Piscis Austrinus, the southern fish.

GRUS

Southwest of Fomalhaut one star of the constellation Grus (Gamma Gruis) appears. A part of this constellation lies below the horizon.

PEGASUS

Pegasus is usually identified by the so-called "Great Square in Pegasus." The location of this square is evident at once from the chart. The star forming one corner of the square is really in the constellation Andromeda and not in Pegasus. This star is Alpheratz. The area within the square is an unusually barren region, and no stars are shown there. There are, however, thirteen stars brighter than magnitude 6.0 and, hence, visible to the naked eye within the square. The star at the northwestern corner of the square is at a corner of a conspicuous triangle of stars. A stream runs southwestward from the lower right-hand corner of the square. The star at the northwestern corner is Beta Pegasi, a star whose brightness varies irregularly from magnitude 2.2 to 2.7. It is a red star. The position of the vernal equinox, that is, the point on the ecliptic at which the sun is when it crosses the equator in the spring, about March 21, is indicated on the chart by a short line (section of the equator). It may easily be found in the sky, approximately, as it is near the point found by extending the eastern side of the great square in Pegasus southward a distance equal to the side of the square.

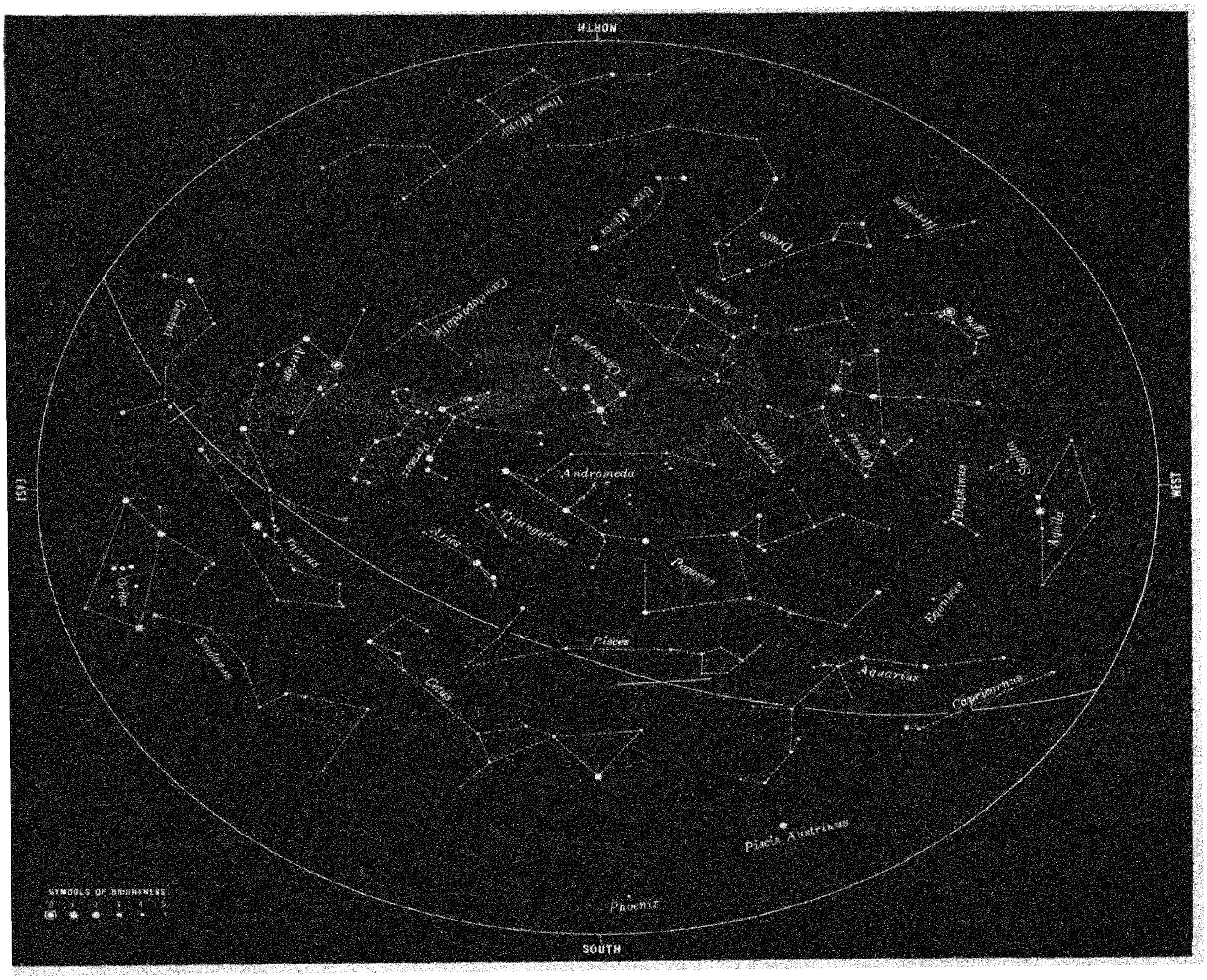
LACERTA

North of Pegasus in the Milky Way lies the unimportant constellation Lacerta.

CEPHEUS

This constellation is in its best position on this chart. It is discussed among the circumpolar constellations on page 19.

CHART 11
NOVEMBER



FOR USE
November 15 from 8 to 10 p. m.
November 1, 9–11 p. m. **November 30, 7–9 p. m.**

For a later hour use Chart 12
For an earlier hour use Chart 10
See page 7

CHART 11

NOVEMBER

The following are the stars brighter than magnitude 1.5 shown on the chart:

VEGA in Lyra	BETELGEUSE in Orion (nearest to east point)
CAPELLA in Auriga	ALDEBARAN in Taurus
RIGEL in Orion	FOMALHAUT in Piscis Austrinus
ALTAIR in Aquila	DENEB in Cygnus

PISCES

Pisces follows Cancer as the next-faintest constellation of the zodiac, but it is an important one, because a long section of the ecliptic lies within it. Just below the great square of Pegasus lies a group of stars of Pisces which form an irregular pentagon. This is the so-called "Circlet in Pisces." Two of the stars, those on the lower side, although marked on this chart, are below our limit of brightness. Some of the other stars are in two streams which form a V. The vernal equinox, that is, the point of the ecliptic at which the sun is when it crosses the equator in the spring, lies in Pisces. A small section of the equator is shown. If one extends the eastern side of the great square in Pegasus southward a distance equal to the side of the square, he will find the vernal equinox near its end.

PHŒNIX

South of the circlet in Pisces, Aquarius and Cetus join. Still farther south is the constellation Sculptor which lies entirely above the horizon but contains no stars bright enough to be shown. South of Sculptor lies Phœnix. Nearly half of the constellation lies below the horizon. Only one star, Alpha Phœnicis, appears on the chart.

ANDROMEDA

In locating Andromeda, it is probably best to find the great square in Pegasus (p. 39) first. A star of Andromeda, Alpheratz, is at one corner of this square. The other bright stars of Andromeda lie in a line running northeastward from Alpheratz. In this constellation, in the position of the cross (+), is the Andromeda Nebula, the brightest and probably the nearest of the spiral nebulæ. To find it, start from Alpheratz and proceed to the third of the stars in the line of bright stars, then, in a direction perpendicular to this line, to the second of the two fainter stars and look for the nebula near this star in the position indicated by the chart. If conditions are good, the nebula may be seen with the naked eye as a faint, cloudy spot.

Its distance from us has been determined, by Dr. E. P. Hubble of the Mt. Wilson Observatory, to be 900,000 light years. It is probably the most distant object seen with the naked eye. The nebula, then, is seen as it was 900,000 years ago. Only those who live 900,000 years from the present time will know what it is like now, for the light now leaving it will not reach the earth until that time. Even the light year is a pretty small unit in which to express such distances. If the scale of the universe were so tremendously reduced that the sun became a sphere of only $\frac{1}{1,000}$ inch in diameter, in which case the earth would be a sphere $\frac{1}{100,000}$ inch in diameter—too small to see in our best microscopes—$\frac{1}{10}$ inch away, the nebula would still be 90,000 miles away.

A photographic plate used with a powerful telescope and with a long exposure shows that the material in this nebula, like that in many other similar objects, is distributed as a central mass with branches of spiral shape extending away from it. In 1924, the outer portions of this nebula and the one in Triangulum were resolved into masses of stars, proving what had been long suspected, that they are great systems of stars, universes, somewhat like the one in which we are but smaller. Thirty billion is the estimate of the number of stars in our system. But the Andromeda Nebula is only one of the spiral nebulæ. It is estimated that a million could be photographed ranging from this, the brightest, to the smallest specks recognizable as nebulæ. How many others there may be, too distant to be seen, no one can tell. The distances of the remotest ones seen are estimated to be 140,000,000 light years. The longest diameter of the Andromeda Nebula is about 45,000 light years. A view of this nebula should be combined with considerable thinking. If it cannot be seen with the naked eye, get an opera glass.

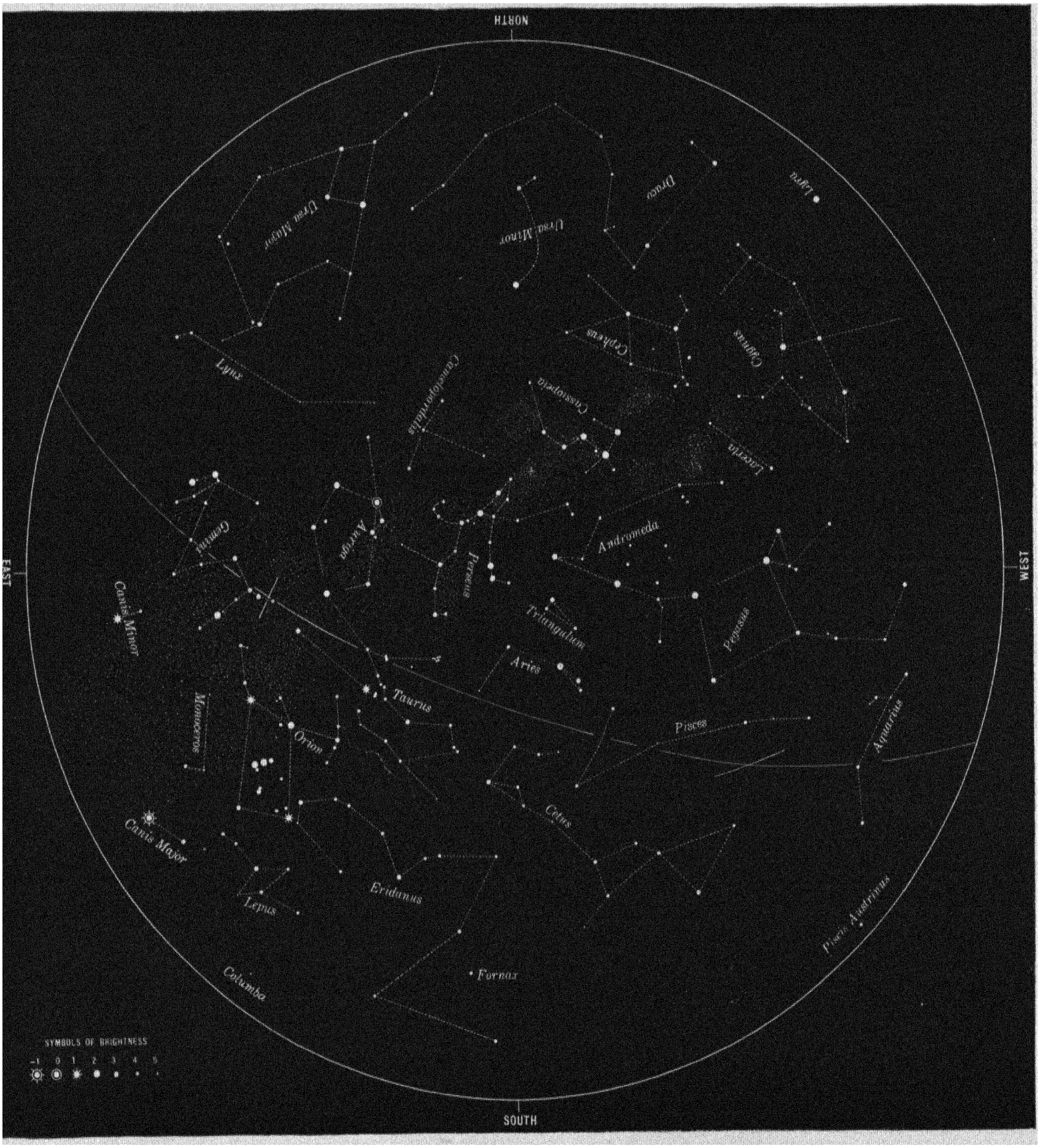
The star just south of the line of bright stars in Andromeda is Epsilon Andromedæ, a star which is approaching us with the high velocity of 51.5 miles a second. The line of bright stars prolonged leads to the brightest star in Perseus but, if bent southward, leads to the very remarkable star Algol in Perseus. This line of stars also helps in locating Triangulum and Aries, which lie south of it. The group of three stars in the northern part of Andromeda is easily identified.

CASSIOPEIA

This constellation is in its best position on this chart. It is discussed among the circumpolar constellations on page 19.

CHART 12

DECEMBER



For use

December 15 from 8 to 10 p. m.

December 1, 9–11 p. m. **December 31, 7–9 p. m.**

For a later hour use Chart 1

For an earlier hour use Chart 11

See page 7

CHART 12

DECEMBER

The following are the stars brighter than magnitude 1.5 shown on the chart:

SIRIUS in Canis Major
VEGA in Lyra
CAPELLA in Auriga
RIGEL in Orion (southern)
PROCYON in Canis Minor
BETELGEUSE in Orion (northern)
ALDEBARAN in Taurus
POLLUX in Gemini (easternmost)
DENEB in Cygnus

ARIES

Although an inconspicuous constellation, Aries is well known by name; and although the constellations of the zodiac make a complete circle and there is really no beginning or end to them, Aries is considered as the first, because at the time at which they were organized, the sun was in this constellation when it crossed the equator. The vernal equinox, the point at which the sun crosses the equator, is often called the "first of Aries." Due to what is called the "precession of the equinoxes," this point is now in the constellation Pisces. Aries is often identified by the triangle in the western part of the constellation.

CETUS

Cetus consists principally of a quadrilateral and two triangles of stars. The star at the western corner of the quadrilateral and the two west of it make an equilateral triangle. Between the quadrilateral and the other triangle lies the remarkable variable star Mira, or Omicron Ceti. Mira varies in brightness in a remarkable way from a magnitude which may be as bright as 1.7 to one which may be as faint as 9.6, and back in a period of about 331 days. The maximum and minimum of brightness and the period vary considerably. When near its greatest brightness it is easily seen with the naked eye, but most of the time it cannot be seen, so it is marked on this chart only. The 1927 maximum, magnitude 4.0, occurred Sept. 26. The star at the corner of the quadrilateral nearest to the horizon is Tau Ceti, which is 10.2 light years away, and the second nearest star shown on these charts.

ERIDANUS

Eridanus consists of a stream of stars extending from 2 degrees above the equator to the horizon and below it. Its brightest star is not visible here. This constellation extends farther in the north-south direction than any other. Several of the nearer stars are in this constellation. Epsilon Eridani, the second star to the right and above the name "Eridanus" on the chart, is 10.5 light years away and third nearest of the stars shown on these charts.

FORNAX

Only one star of this constellation, Alpha Fornacis, appears on the chart, although the whole constellation is above the horizon.

TRIANGULUM

The three stars just above the triangle in Aries are the principal stars in this constellation. It contains a very fine spiral nebula.

PERSEUS

The constellation Perseus is one of those in the Milky Way. Some of the stars in the constellation are arranged in the form of the letter $\mathcal{A}$, as seen on the chart. The eastern side of the $\mathcal{A}$ forms the so-called "Segment in Perseus." A long stream of stars of Perseus extends from Cassiopeia to the Pleiades in Taurus. Just north of the top of the $\mathcal{A}$, the double cluster in Perseus may be seen on a dark night as two hazy spots. The position is marked by a cross on the chart. The star next but one to the bottom end in the western side of the $\mathcal{A}$ is the eclipsing variable star Algol, or Beta Persei. This star consists of two stars one of which eclipses the other at regular intervals of 2 days, 21 hours. The star remains at approximately magnitude 2.1 for 2 days, 11 hours, then decreases in brightness to magnitude 3.2 in 5 hours and returns to its original brightness in another 5 hours. Of course, many of the eclipses occur in the daytime. The star next to the end is Rho Persei, which is also variable. Its magnitude varies irregularly from 3.4 to 4.2.

THE ZODIACAL LIGHT

The "zodiacal light" is the name applied to wedges of faint light seen along the zodiac on either side of the sun. It is brightest and widest near the sun. Some such faint light extends entirely around the zodiac, but rarely can it be seen more than 90 degrees from the sun. The region exactly opposite to the sun is somewhat brighter than other parts far from the sun. This spot is called the **Gegenschein.** It is very difficult to see. The appearance of the zodiacal light is like that of the Milky Way, except that in most parts it is not so bright. Its brightness changes somewhat from time to time. Since the zodiacal light is faint at best, it is important that the observer should select the best conditions for observing. Of course, he should select a station away from artificial lights and a clear dark night. Since the zodiacal light is brightest near the sun, he should observe just after the evening twilight ends

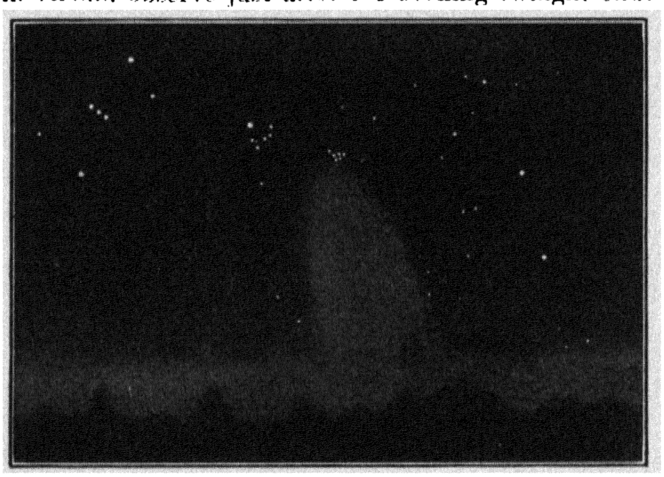


FIG. 3.—The Zodiacal Light as seen in the evening.

or just before the morning twilight begins. The absorption of light by the earth's atmosphere, which we have discussed, is a very important factor here, for the zodiacal light is brightest near the horizon where the absorption is greatest. To minimize the effect of the absorption, he should select a time when the ecliptic, which bisects the zodiac, is as nearly as possible perpendicular to the horizon. The ecliptic has this position when the vernal equinox is on the western horizon. This is the position of the celestial sphere at 9 p.m., Feb. 5, and at 3 a.m., Nov. 7. Detail Chart *A*, page 53, shows the celestial sphere in this position. Chart 2 represents the condition more nearly than any other of the numbered charts. Chart 8 shows the ecliptic in an unfavorable position. If the ecliptic were in this position when evening twilight ends or morning twilight begins, the zodiacal light would lie so close to the horizon that it would be obliterated by the atmospheric absorption.

Therefore, observations should be made just after twilight ends in the evening, in February or March. The zodiacal light will then extend from the western horizon up in the general direction of the Pleiades. Figure 3 is a drawing of the zodiacal light as seen at this time. Morning observations should be made just before twilight begins, during September or October. The zodiacal light then extends from the eastern horizon up in the general direction of the bright star Regulus in the constellation Leo. It is probably best not to look for the zodiacal light until the constellations have been studied and these stars are known. The best way to notice the evening zodiacal light is to sweep the sky with the eyes from northwest to southwest about 20 degrees from the horizon. The change from the dark sky to the lighter region of the zodiacal light or the reverse then becomes quite noticeable, whereas, if one looks only in the direction of the zodiacal light, he will notice nothing; a similar method applies to morning observations. The zodiacal light is caused by the reflection of sunlight from a vast swarm of particles or perhaps larger bodies revolving about the sun nearly in the plane of the earth's orbit and extending out beyond the earth.

COMETS

Occasionally, comets are bright enough to be seen easily with the naked eye. A normal comet exhibits a circular, cloudy spot of light—the head—at the center of which a telescope reveals a brighter, starlike point of light—the nucleus—and a train of light which becomes fainter and wider with increasing distance from the head—**the tail.** Some show no nucleus and some have no tail. They range in brightness from those which are bright enough to be seen in broad daylight to those which at best can barely be seen in large telescopes; and no doubt, still fainter ones exist. The same comet rises from invisibility to its greatest brightness as it approaches the earth and sun and then falls to invisibility again as it recedes from them. The tail always points away from the sun, that is, it follows the head in approaching the sun and precedes it when leaving the sun.

Comets move about the sun in elongated ellipses with the sun (and earth) near one end of their orbits. They are not bright enough to be seen except when relatively near, and by far the greater number are never bright enough to be seen with the naked eye. Few are conspicuous. Some move in ellipses which are relatively short and so, return to the vicinity of the sun at short intervals. The briefest period known is 3.3 years. The longest period known with certainty is that of Halley's famous comet, which averages 77 years. Its last return was in 1910, and its next will be in 1987 or thereabout. Figure 4 gives a view of this comet as it appeared in 1910, and although few are as conspicuous as this one, it will serve to give an idea of their appearance in general.

Halley's comet is the only one, the return of which can be predicted with confidence as to time and position, conspicuous to the naked eye. Others which are to become conspicuous must be discovered, no one knows when or where. Indeed most of them appear unexpectedly, and some observers specialize in hunting for them. As recently as 1910, a comet was discovered by laymen with the naked eye and reported to astronomers, but it is very unusual now for one to become so bright before detection. They may be seen in any part of the sky and are not necessarily within the zodiac, as is the case with the planets. They are not at all like

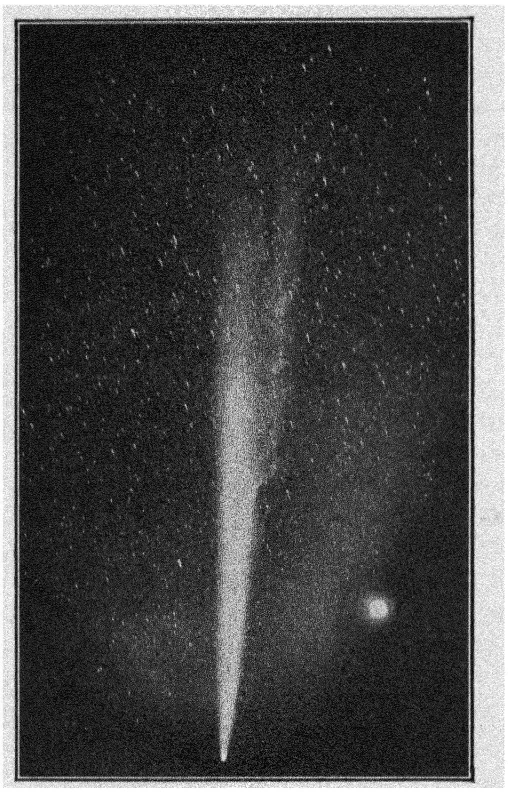


FIG. 4.—Halley's Comet, May 13, 1910. (*From photograph made at the Lowell Observatory. The object on the right is the planet Venus.*)

stars in appearance, as is shown in Fig. 4, but, when without a visible tail, resemble nebulæ. The nebula in Andromeda, visible faintly to the naked eye (see p. 41) and Præsepe in Cancer (see p. 25) have frequently been mistaken for comets by amateurs. When a comet is sufficiently bright to be seen with the naked eye, it arouses considerable interest, and information concerning its position perhaps a statement as to the constellation in which it lies at the time is likely to be found in the newspapers.

METEORS

If one looks at the sky on a clear, dark night, he will frequently see what seems to be a star darting rapidly a short distance across the sky and then vanishing. These objects are called by astronomers **meteors** but are popularly known as "shooting stars." The latter term is somewhat objectionable, as they are not stars at all. The few which are brighter than stars of the first magnitude are given the special name **fireballs.** Sometimes the material which makes up fireballs falls on the earth in the form of irregular, solid pieces, like stones or masses of iron, called **meteorites.**

Meteors vary much in appearance. Some have luminous trains, some emit sparks, and some move in wavy paths. The usual color is white or yellow. The bright ones may show vivid red and green. Sound may accompany the appearance of a fireball. Sometimes a large number appear on the same night, or perhaps for several consecutive nights, moving radially away from the same point among the stars. Such meteors constitute a **meteoric shower,** and the point from which they seem to move is called the **radiant.** These showers may be expected on the same date each year, but there may be great differences in the number of meteors seen in different years. A few of the more conspicuous of these showers, with their dates, are as follows (the constellations in which their radiants lie are indicated by the names): **Draconids, Jan. 2; Lyrids, Apr. 20; Aquarids, May 6; Perseids, Aug. 12; Orionids, Oct. 20; Leonids, Nov. 14; Andromedids, Nov 24; Geminids, Dec. 10.** In some cases, the showers extend over several days, and in any case, it is well to look also a night or two before and after the dates given.

There are many meteors which apparently do not belong to any shower. Meteors are most frequent about 3 a. m. and there are about twice as many seen after midnight as before. They are most frequent in the autumn and more frequent in the east than in the west. The ordinary meteor is a very small mass which, in flying through space, collides with the earth's atmosphere and is heated to incandescence by the friction and reduced to dust by the heat.

TEMPORARY STARS

Occasionally, a star appears suddenly in a position in which no star was seen before even with a telescope (or if at all, much more faintly) and, after increasing greatly in brightness in a very short time, decreases in brightness more or less irregularly and less rapidly, until it is very faint again, perhaps too faint to be seen at all. Such stars are called **temporary stars.** They are also called **novæ** and, somewhat ineptly, "new stars." The appearances of about fifty have been recorded in all time to date, most of them in recent centuries. All of the early ones, of course, were visible to the naked eye. Five have become at least as bright as magnitude 1.5 since 1900. One, in 1918, became almost as bright as Sirius, the brightest fixed star, and was discovered independently by many, amateur as well as professional

astronomers. The brightest of them could have been, and usually were, discovered with the naked eye. Almost all of them have appeared in the Milky Way. The discovery of such a star should be reported to an astronomer immediately, as they are very anxious to oberve them in the early stages of their rise in brightness. No star brighter than the tenth magnitude has been known to become a temporary star. No star has been known to rise in brightness and become a star permanently visible where none was known before, nor has any star known for a long time been known to disappear, although claims have been made that each of these phenomena has occurred. No star has been known to manifest more than one outburst. The cause of the phenomenon is still very much of a puzzle.

OTHER PHENOMENA

There are various phenomena of the earth's atmosphere in which the sun or moon play a conspicuous part, which will be only briefly mentioned here. Rainbows are caused by the refraction and dispersion of the light of the sun or moon by raindrops. Lunar and solar halos (ring around the moon and sun, moon dogs, sun dogs) are caused by the reflection and refraction of the light of the moon and sun from crystals of ice in the atmosphere. An aurora borealis is caused by an electrical action of the sun on the upper atmosphere.

THE CONSTELLATION FIGURES

The names of the constellations rarely help in calling to mind the arrangement of the stars in them, and for this reason, we have paid little attention to the constellation figures, that is, to the lines which delineate the creatures or objects which give the constellations their names. The names of many of the constellations can be traced back to prehistoric times. Just what were the relations of the stars to the figures in the imaginations of these ancient peoples we do not know. Our most ancient reliable source of information is the catalogue of Ptolemy, 150 A.D., in which he gives the positions of 917 stars with respect to the forty-eight constellation figures in which they are. Thus, Aldebaran is noted as the star in the southern eye; Polaris, as the star at the end of the tail; and Mizar, as the middle star of the three located in the tail. The Arabs were the preservers of astronomical knowledge during the dark ages. Their translations of Ptolemy's descriptions or similar descriptions, corrupted in form, have frequently become the names of stars. Thus, *Deneb* means the "tail," *Rigel* means the "foot;" and *Betelgeuse* means the "armpit of the central one." Before Bayer's system of naming stars was introduced (see pp. 5 and 51), the common way of designating stars was by their positions in the constellation figures, following the plan of Ptolemy. With the change in the system of naming stars, the attempts to trace out the constellation figures in the sky have no useful purpose.

Ptolemy states that he frequently altered the constellation figures from those in use before, that they might better represent the forms of the things for which they are drawn and that those who had preceded him had also done this. There are in existence no globes or drawings showing the constellation figures of ancient origin. The source of our present figures are drawings by the celebrated artist Dürer, published in 1515. His drawings were based on Ptolemy's descriptions, and they have been reproduced with but few changes by those who have represented them since that time. The constellation figures were usually drawn on celestial globes and star charts in the past, but now they are usually omitted. Interest in them is chiefly historical and mythological rather than astronomical. We give only samples of them. In Fig. 5 are shown the figures for the circumpolar constellations, adapted from Heis's *Atlas Coelestis Novus*.

Immediately upon seeing these figures, one is led to remark, "Why should anyone associate those groups of stars with bears? Even now that I see the bears drawn, I do not see any reason for the association." No, nor does anyone, now at least. The stars seem to be in no especial points in the anatomy of the bears. In the case of the larger bear, we may note that there are pairs of stars in three of the four paws (the three pairs mentioned on p. 27) but that the paws of the smaller bear are void of stars. There is a faint star (not shown) in one paw, but that happens to be the paw which is empty in the larger bear. There are three stars which form a beautiful tail for each of the bears, but the artist has wisely drawn these bears with two tails each——one a tail such as real bears have, short and stubby, an "apology for a tail," to use a common expression, and the other the tail of the imaginary bear, which needs still more of an apology. So we conclude that we could draw many figures about these stars, which would be just as suitable as bears.

But a group of at least some of these stars have been known as a bear from prehistoric times, in widely scattered parts of the earth, even among the North American Indians. The bear is mentioned by the ancient Greek poets, Homer and Hesiod, and also in the Bible (revised version) in Job 9: 9, "That maketh the Bear, Orion, and the Pleiades," and in Job 38: 32, "Or canst thou guide the Bear with her train?"

The ancient constellations included only the stars within the bounds of the constellation figures. Ptolemy's list includes 108 stars, which he marks "unformed," that is, not contained in any constellation. Now, the boundaries are taken to be outside the constellation figures, to include all stars and to fill the

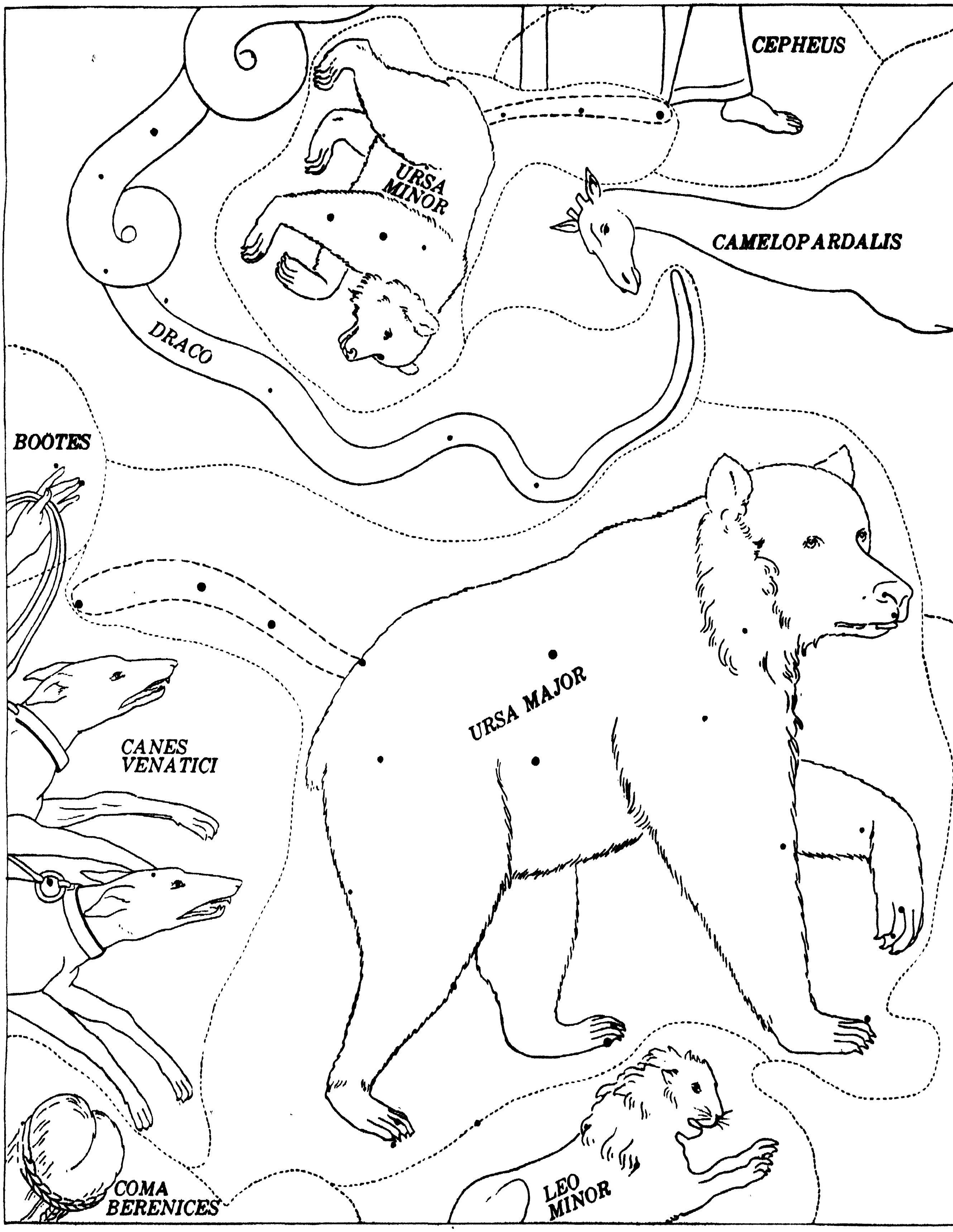


Fig. 5.—The North Polar Constellation Figures.

sky. Some of the stars marked unformed by Ptolemy, which are near Ursa Major, were used by Hevelius (1690) to form the new constellations Canes Venatici, Leo Minor, and Lynx; and Bartschius, in 1614, formed Camelopardalis to fill a large, almost empty place. Thus, the constellations became areas rather than figures. The boundaries of the constellations as well as the figures are marked on Fig. 5. The boundaries of all constellations will be found on the detail charts of parts II and III. The irregularity of the constellation figures explains the irregularities of these boundaries.

Of Ptolemy's forty-eight constellation figures, fourteen, including Centaurus, represent men and women; three are birds; fourteen, other land creatures; seven, water creatures; and ten, inanimate objects.

The present list of eighty-eight constellations adds only one man, Indus (Indian), a constellation not visible here, and one woman, if we so count Coma Berenices (Berenice's hair), sixteen men and women in all. There are nine birds, one insect, Musca (the fly), not visible here, twenty-two other land creatures, ten water creatures, and thirty inanimate objects. The additions are chiefly in the last group.

MYTHOLOGY

There are many myths originating in different countries, connected with the stars. There are myths upon which the constellation figures have been based or myths to explain their existence. There is little in this connection which is not in the nature of tradition. The real reasons for the formation of the ancient figures—and there are evidences of a plan in their formation—are lost in antiquity. The problem of discovering them is one for the archæologist and the philologist rather than the astronomer. These myths have played an important part in the literature and art of ancient and modern times, which is evidence that many have found them interesting. Whole volumes have been written upon them. As this subject is rather apart from the purpose of this book, we must pass over it very briefly and refer readers particularly interested to other books (see page 70). The myths, of course, are connected only with the ancient constellations.

The Greek myth is that Juno, being jealous by reason of Jupiter's attentions to the beautiful woman, Callisto, had her changed to a bear. Callisto, roaming in this form, met her son, Arcas, hunting and, desiring to embrace him, approached him and he, not recognizing her in this form, was about to kill her, when Jupiter, to avert the catastrophe, snatched up both and placed them in the sky as the greater and smaller bears, **Ursa Major and Ursa Minor.** Juno, enraged at the honors thus bestowed upon them, appealed to Tethys and Oceanus, the powers of the ocean, and induced them to forbid the couple to enter their domains. Consequently, the bears move around the heavens without disappearing (setting) beneath the ocean.

Old Thomas Hood, about 1600, suggested the following reason for the great length of the tail of the greater bear, and a similar one will apply in the case of the smaller bear:

> Imagine that Jupiter, fearing to come too nigh unto her teeth, layde hold on her tayle, and thereby drewe her up into the heaven; so that shee of herself being very weightie, and the distance from the earth to the heavens very great, there was great likelihood that her taile must stretch.

The Greek word for "bear" is *arktos*. This is the source of our adjective, *arctic*, relating to the region of the north pole. Others called the group of seven stars in Ursa Major a wagon or a plough—names which are still used. By association with the plough, the seven stars became seven oxen, and the constellation became *Septentriones* to the Romans, a Latin word meaning the "seven plough oxen." This is the source of the adjective, *septentrional*, meaning "northern." Mizar and Alcor, the middle star of the tail and its faint and close companion, have proved interesting. To those who regarded the group as a wagon drawn by a train of horses, they became the "horse and his rider," and Alcor became the "little starry horseman" and "Jack on the middle horse." To the North American Indians, the tail was three hunters chasing the bear, and Alcor was the pot in which to cook her. To some Greeks, Alcor was the lost Pleiad.

Ursa Minor, in early times, was called *Cynosura*, which means "dog's tail." Later, the name was applied to the star Polaris in the constellation. As mariners watched this star, the North Star, in order to determine directions, as already explained (p. 18), the word *cynosure* came into use, to mean anything which attracts general attention.

Cepheus, whose foot appears on Fig. 5, was the king of Æthiopeia, **Cassiopeia** was his wife, the queen, and **Andromeda,** their daughter. Cassiopeia boasted that her beauty surpassed that of the sea nymphs, a boast which so offended them that they had Neptune send a great sea monster, **Cetus,** to ravage their coast. Cepheus was directed by the oracle of Ammon to expose Andromeda on the coast to be devoured by the monster. Accordingly, she was chained to a rock on the shore. As the monster approached, the hero **Perseus,** returning in winged shoes given him by Mercury, from his adventure with Medusa (see below), discovered her plight, killed the monster after a great battle, and, of course, married Andromeda.

Cassiopeia after her death, with the others was placed among the stars, but her enemies, the sea nymphs, had

her placed near the pole where half of the time she is in a humble position—head downward. Cassiopeia is represented as seated on a throne. Some see a chair with an irregular back formed by the stars in the constellation, but it should be pointed out that the chair in which Cassiopeia sits is in a very different position. The constellation is frequently called "Cassiopeia's chair." Andromeda is frequently called the "chained lady," and Perseus, the "champion." Cepheus plays no important part in the story, a fact which agrees with the inconspicuousness of the constellation in the sky. These constellations adjoin each other, excepting Cetus.

Perseus was the son of Jupiter and Danaë. He was sent to attempt to conquer Medusa. Medusa was one of three sister monsters, called "Gorgons," who had huge teeth, great claws, and serpents as hair. All who looked upon Medusa were turned to stone at the sight. Perseus was loaned Minerva's shield and Mercury's winged shoes, and, thus equipped, taking care not to look at Medusa but only at her image reflected from the shield, he cut off her head. He took this head with him, and when he rescued Andromeda, used it to slay the monster and later, other enemies, for still those who looked upon it were turned to stone. He is pictured holding the head of Medusa.

Pegasus was a wonderful snow-white horse with wings, which, at the command of Neptune, sprang from the blood of Medusa which had dropped into the sea after Perseus had severed her head. Only the head, wings, shoulders, and front feet are shown in the constellation figure.

One of the great-grandsons of Perseus and Andromeda was **Hercules,** celebrated for his great adventures, the "twelve labors of Hercules." These labors probably have some connection with the passage of the sun through the twelve signs of the zodiac, but the connection is not clear. Hercules is represented as kneeling, with his left foot on **Draco** and wearing a lion's skin. The slaying of the Nemean lion, **Leo,** was Hercules's first labor. The eleventh labor was the capture of the golden apples from the garden of the Hesperides, where they were guarded by the ever watchful dragon, Ladon. **Draco** is this dragon, which, since it does not set, may be considered as ever on the alert. It is claimed that Hercules with his foot on Draco depicts the story of the Garden of Eden—"I will put enmity between thee and the woman, and between thy seed and her seed: he shall bruise thy head and thou shalt bruise his heel" (Gen. 2:15). The claim is supported by the presence of the garden and the apples. A part of Draco, but not the head, is included in Fig. 5. It is not clear why the hero should be in the rather surprising posture of kneeling, but the posture is of some consequence, since he was known as the "kneeler," even in very early times. It is curious and probably significant that just south of Hercules lie **Ophiuchus** and **Serpens,** another man and snake, with the foot of Ophiuchus on **Scorpius,** and the heads of the two men adjacent. The latter pair, however, is usually associated with the mythical god of medicine, Æsculapius, and the serpent, the symbol of renovation, commonly associated with his worship. When Æsculapius brought the dead to life, Pluto, fearing that he might make men immortal, had Jupiter kill him with a thunderbolt and place him among the constellations.

The second of the labors of Hercules was the destruction of the **Hydra.** The Hydra was a monster with nine heads, the middle one being immortal. Each time that Hercules knocked off a head with his club, two heads grew in its place. At last, he burned them off and buried the immortal one under a rock. The Hydra, as pictured in the constellation figure, has but one head. Hercules dipped his arrows in the monster's blood, which proved to be deadly poison. One day, one of these arrows accidentally struck Chiron, the centaur, his teacher, whereupon Chiron was placed by Jupiter among the constellations as **Centaurus.** Centaurs were creatures half man and half horse. Chiron, the greatest, was very proficient in many branches of learning and was the teacher of several of the mythological heroes. While Hercules fought the Hydra, a crab pinched his toes, but he crushed it with his heel. Juno, his enemy, had the crab placed in the sky as a constellation, **Cancer,** as a reward for the service.

Sagittarius is another constellation represented as a centaur and also said to be Chiron but of apparently earlier origin.

Coming back now to Perseus—after this hero had slain Medusa, as already related, he flew far and wide and eventually came to the kingdom of Atlas. Atlas was an immense giant, rich and without rival in his remote domain. His chief pride was in the garden of the Hesperides in which grew golden apples on golden branches. Perseus wished to stay with him overnight and disclosed that he was a son of Jupiter and told of slaying Medusa. But Atlas recalled a prophecy that a son of Jupiter should rob him of his apples (that Hercules did this has been related), so he refused to entertain him. Perseus then offered him a present, the head of Medusa. As Atlas looked upon it, like others, he was turned to stone and became a great mountain, with the heavens resting upon his shoulders. He is often pictured carrying the earth or sky on his shoulders, and his name is given to one of the vertebræ of the neck about where the globe rests, and also to any collection of large charts.

We are interested also in the daughters of Atlas. The most famous of these are the seven sisters, commonly called the **Pleiades**—Alcyone, Calæno, Elec-

tra, Maia, Merope, Sterope, and Taygeta. Their mother was Pleione. They are immortalized in the sky as the group of stars discussed on page 21. Viewing the group as a little dipper, Atlas is the handle; Alcyone, the brightest star, the one where the handle joins the bowl; Merope and Electra, the stars in order at the bottom of the bowl; and Maia, the fourth star of the bowl; with Taygeta near-by. The names of the mother and of the other sisters are applied to fainter stars. Tradition says that seven stars were once seen, and various explanations are given to account for the "lost Pleiad." There is as much uncertainty as to which one is lost as there is as to what happened to her. Electra is said to have placed her hands over her face so she should not witness the fall of Troy or else to have left to witness it and then become the star Alcor. Merope married a mortal, then repenting, it is said, hid her face in shame. Calæno is said to have been struck by lightning. Sterope and the mother, Pleione, are each also accused of being the lost Pleiad.

There is a myth that **Orion** became infatuated with the "seven sisters" and pursued them until Jupiter, in pity, changed them into pigeons and then placed them and Orion and his dogs, **Canis Major** and **Canis Minor,** in the sky as constellations. The Pleiades are frequently compared to a hen and chickens or to a flock of birds.

The time when the Pleiades cross the meridian at midnight, Nov. 17, was a time of especial importance to those who worshiped them. At this time they rise about sunset. They rise at sunrise in May. These events divide the year into two great seasons, winter and summer. The month of November was, and still is, a special time for commemorating the dead. All Saints' Day, Allhallow Eve, and All Souls' Day are connected with the Pleiades.

The **Hyades** were the daughters of Atlas and Æthra and, hence, half sisters of the Pleiades. They are six in number but, as with the Pleiades, there were supposed at one time to have been seven. Their names have not been given to individual stars, and they are much less important mythlogically than the Pleiades. Both groups are a part of **Taurus,** the Bull. The Hyades are in his head, and the Pleiades rest on his shoulders, in fact, only the front part of the bull is pictured.

Taurus is a very ancient constellation and an important one, since the vernal equinox was in it from about 4000 to 1700 B.C. The twelve constellations of the zodiac have some connection with the twelve tribes of Israel, and Taurus seems to have been associated with Joseph. The sacred bull of Egypt, the golden calf, and so forth, are witness to the importance of the bull in ancient times. The Greeks say that Jupiter, having become enamored of the beautiful maiden, Europa, took the form of a snow-white bull and mingled with her father's herds. She, encouraged by his tameness and attracted by his unusual beauty, sat upon his back, whereupon he carried her away and swam with her from Phœnicia, her home, to Crete. As his body was largely immersed while swimming, only the head and forepart appear in the constellation figure.

Another story about Orion is that he was a mighty hunter and boasted that he could overcome any beast; but he was killed by the sting of **Scorpius,** and both were placed in the sky, as far apart as possible. Orion is mentioned in the Bible, in Job 9:9, already quoted, and in Job 38: 31. "Canst thou bind the cluster of the Pleiades, or loose the bands of Orion?" and in Amos 5: 8, "*Seek him* that maketh the Pleiades and Orion."

Canes Venatici, the Hunting Dogs, is a modern constellation with no mythology. Their heads are shown in Fig. 5, with the cords by means of which they are held in leash by **Boötes,** the Hunter, who is in pursuit of the Bear, Ursa Major. Boötes is also said to be a herdsman, and a wagoner, the driver of the wagon to which Ursa Major is often compared. Its brightest star is *Arcturus*, a name which means "bear guard." Strangely, Ptolemy did not include this very bright star in any constellation.

Camelopardalis and **Leo Minor,** shown on Fig. 5, being modern constellations, have no mythology. **Coma Berenices** is an ancient constellation in name but one not definitely recognized until 1602. It was invented about 243 B.C. to console Berenice, queen of Ptolemy Euergetes, for the theft of some locks of her hair from the temple of Venus.

Auriga is represented as a charioteer holding a whip in one hand and supporting a goat and three kids with his left arm and shoulder. This curious group is not explained. **Lyra** is said to be the lyre, or harp, of the famous mythical musician Orpheus. The musician himself at his death is said to have been changed to a swan, **Cygnus,** and placed in the heavens near his harp. Jupiter, in the form of an eagle, **Aquila,** is said to have carried off a Trojan boy, Ganymede, to be cupbearer to the gods. The twins, **Gemini,** are now usually accepted to be Castor and Pollux, sons of Jupiter and Leda and brothers of the famous Helen, whose beauty caused the Trojan war. On the voyage to that war a great storm arose. Orpheus played on his harp and prayed to the gods. When the storm ceased, the stars appeared on the heads of the brothers. Thereafter, they were the patron deities for seamen. This explains the interesting reference in the Bible, Acts 28: 11, "we set sail in a ship . . . whose sign was The Twin Brothers." They were especially dear to Romans, as Jupiter had appointed them guardians of the city. The Romans often swore by Gemini and the oath in corrupted form is our present-day "by Jiminy."

PART II

DETAIL CHARTS AND DISCUSSION

Charts 1 to 12 were designed for beginners in constellation study and were kept as free as possible of congestion and confusing details. On page 5, we described Bayer's system of designating stars in the constellations by letters. For the convenience of those who wish to use the Greek letters and to know the approximate right ascensions and declinations (defined below) of the stars or the boundaries of the constellations we add three charts made on the same general plan as charts 1 to 12. We call them detail charts *A*, *B*, and *C*. These details will be needed by those who read astronomical literature, such as textbooks, in which the Greek letters are frequently used. Probably, no one not already familiar with the constellations will care to use charts *A*, *B*, or *C*; hence, to relieve congestion, we have used on them the abbreviations of the names of the constellations recommended by the International Astronomical Union, in 1922. These three-letter abbreviations will usually suggest the full names of the constellations at once. The positions of the stars and the lines joining them should also suggest the names of the constellations, as they are the same as on charts 1 to 12. The full name can be obtained from one of those charts or from Table II, except in the case of Sex, which stands for Sextans, a constellation in which no stars are bright enough to appear on the charts.

In order to use Bayer's system, it is necessary to know the Greek alphabet, especially the first letters, which are used for the brighter stars. The Greek alphabet (small letters) is as follows:

α alpha	ι iota	ρ rho
β beta	κ kappa	σ sigma
γ gamma	λ lambda	τ tau
δ delta	μ mu	υ upsilon
ϵ epsilon	ν nu	φ phi
ζ zeta	ξ xi	χ chi
η eta	o omicron	ψ psi
θ theta	π pi	ω omega

It is necessary also to know the names of the constellations in the genitive case. Table VII, below, gives these names for the constellations shown on the charts of Part I or on those of Part II, in the first column. The names of the same constellations, excepting Sextans (Seks'tans), are given and in the same order in Table II, page 10. The second column gives the pronunciation, and the third column gives the three-letter abbreviation which is based on the genitive case. Thus, α Coronæ Borealis may be written very briefly α CrB. The last column gives the letter of the chart *A*, *B*, or *C* on which the constellation is in its best position.

TABLE VII.—CONSTELLATION NAMES IN THE GENITIVE CASE

Constellation name genitive case	Pronunciation	Abbreviation	Best chart
Andromedæ	An-drom'e-dē	And	*C*
Aquarii	A-kwā'ri-ī	Aqr	*C*
Aquilæ	Ak'wil-ē	Aql	*C*
Arietis	A-rī'e-tis	Ari	*A*
Aurigæ	A-rī'gē	Aur	*A*
Boötis	Bo-ō'tis	Boo	*B*
Camelopardalis	Ka-mel-o-par'da-lis	Cam	*A*
Cancri	Kan'krī	Cnc	*A*
Canum Venaticorum	Kā'num Ve-nat-i-kō'rum	CVn	*B*
Canis Majoris	Kā'nis Ma-jōr'is	CMa	*A*
Canis Minoris	Kā'nis Mi-nōr'is	CMi	*A*
Capricorni	Kap-ri-kor'nī	Cap	*C*
Cassiopeiæ	Kas-i-ō-pē'yē	Cas	*C*
Centauri	Sen-taw'rī	Cen	*B*
Cephei	Sē'fē-ī	Cep	*C*
Ceti	Sē'tī	Cet	*A*
Columbæ	Ko-lum'bē	Col	*A*
Comæ Berenices	Kō'mē Ber-e-nī'sēz	Com	*B*
Coronæ Borealis	Kō-rō'nē Bo-re-āl'is	CrB	*B*
Corvi	Kor'vī	Crv	*B*
Crateris	Krā'ter-is	Crt	*B*
Cygni	Sig'nī	Cyg	*C*
Delphini	Del-fī'nī	Del	*C*
Draconis	Drā-kō'nis	Dra	*B*
Equulei	E-kwoo'le-ī	Equ	*C*
Eridani	E-rid'a-nī	Eri	*A*
Fornacis	For-nak'is	For	*A*
Geminorum	Jem-i-nō'rum	Gem	*A*
Gruis	Groo'is	Gru	*C*
Herculis	Her'kū-lis	Her	*B*
Hydræ	Hy'drē	Hya	*B*
Lacertæ	La-ser'tē	Lac	*C*
Leonis	Lē-ō'nis	Leo	*B*
Leonis Minoris	Lē-ō'nis Mi-nōr'is	LMi	*B*
Leporis	Le'por-is	Lep	*A*
Libræ	Lī'brē	Lib	*B*
Lupi	Lu'pī	Lup	*B*
Lyncis	Lin'kis	Lyn	*A*
Lyræ	Ly'rē	Lyr	*C*
Monocerotis	Mo-nos-e-rō'tis	Mon	*A*
Ophiuchi	Of-i-ū'kī	Oph	*B*
Orionis	O-ri-ō'nis	Ori	*A*
Pegasi	Peg'a-sī	Peg	*C*
Persei	Per'se-ī	Per	*A*

TABLE VII.—CONSTELLATION NAMES IN THE GENITIVE CASE (*Continued*)

Constellation name genitive case	Pronunciation	Abbreviation	Best chart
Phœnicis	Fē-nī'kis	Phe	*C*
Piscium	Pis'i-um	Psc	*C*
Piscis Austrini	Pis'iz Aus-trī'nī	PsA	*C*
Puppis	Pup'pis	Pup	*A*
Pyxidis	Pyx'i-dis	Pyx	*A*
Sagittæ	Saj-i'tē	Sge	*C*
Sagittarii	Saj-i-tā'ri-ī	Sgr	*C*
Scorpii	Skor'pē-ī	Sco	*B*
Scuti	Skū'tī	Sct	*C*
Serpentis	Ser-pent'is	Ser	*B*
Sextantis	Seks-tant'is	Sex	*B*
Tauri	Taw'rī	Tau	*A*
Trianguli	Tri-ang'gu-lī	Tri	*A*
Ursæ Majoris	Er'sē Ma-jōr'is	UMa	*B*
Ursæ Minoris	Er'sē Mi-nōr'is	UMi	*B*
Velorum	Vē-lōr'um	Vel	*A*
Virginis	Ver'ji-nis	Vir	*B*
Vulpeculæ	Vul-pec'u-lē	Vul	*C*

For various reasons, the series of Greek letters found in the constellations are not always continuous, and in not many cases are they complete. In some cases, the same Greek letter is used for several stars, and to distinguish them, small numerals are written above the letters. In Orion, for instance, there are six stars given the letter π, four of which are shown on the charts. This is an exceptional case. The names of these are read as Pi Two Orionis, Pi Three Orionis, and so forth, according to the numeral. Stars which have not been assigned Greek letters are designated in other ways—by Latin letters, by the number of the star in some catalogue, and so forth. A few such are shown on the charts, but they are not bright stars, and the designations have been omitted, except that the variable stars R Lyræ and R Hydræ, which were mentioned in the text, have been marked.

THE LINES ON CHARTS *A*, *B*, AND *C*

The circular boundary, as in charts 1 to 12, represents the horizon. The north celestial pole is at the intersection of the two lines which intersect near Polaris (α Ursæ Minoris). On each chart *A*, *B*, and *C*, there is a curved line, heavier than the others, which meets the horizon at the east and west points. This line represents the celestial equator. The celestial equator bears the same relation to the celestial sphere that the equator does to the earth. On the charts are drawn a number of lines which represent circles parallel to the celestial equator. They are called **parallels of declination** and correspond to parallels of latitude on the earth. There are also curves which represent circles perpendicular to the celestial equator. If completely drawn, these lines would meet at the point representing the celestial pole. These are called **hour circles,** and they correspond to meridians on the earth. The dotted line which crosses the charts in the general east-west direction, at a varying distance from the equator, represents the ecliptic, the apparent path of the sun. This is also shown on charts 1 to 12.

As stated on page 4, a constellation is strictly an area on the sky with a boundary which is usually irregular. The irregular, faint lines found on these detail charts mark the boundaries of the constellations shown. The names of constellations not entirely above the horizon, in which no stars are shown, are not indicated. Of course, many fainter stars can be seen with the naked eye in the regions in which none is shown. To relieve congestion, the Milky Way is not shown on the detail charts.

RIGHT ASCENSION AND DECLINATION

Since we have described the same kind of circles on the celestial sphere which are used on the earth, we can indicate the position of a star or other heavenly body in quite the same manner as that used to indicate the position of a point on the surface of the earth, and this is done by stating its longitude and latitude. The corresponding coordinates on the celestial sphere are called "right ascension" and "declination."

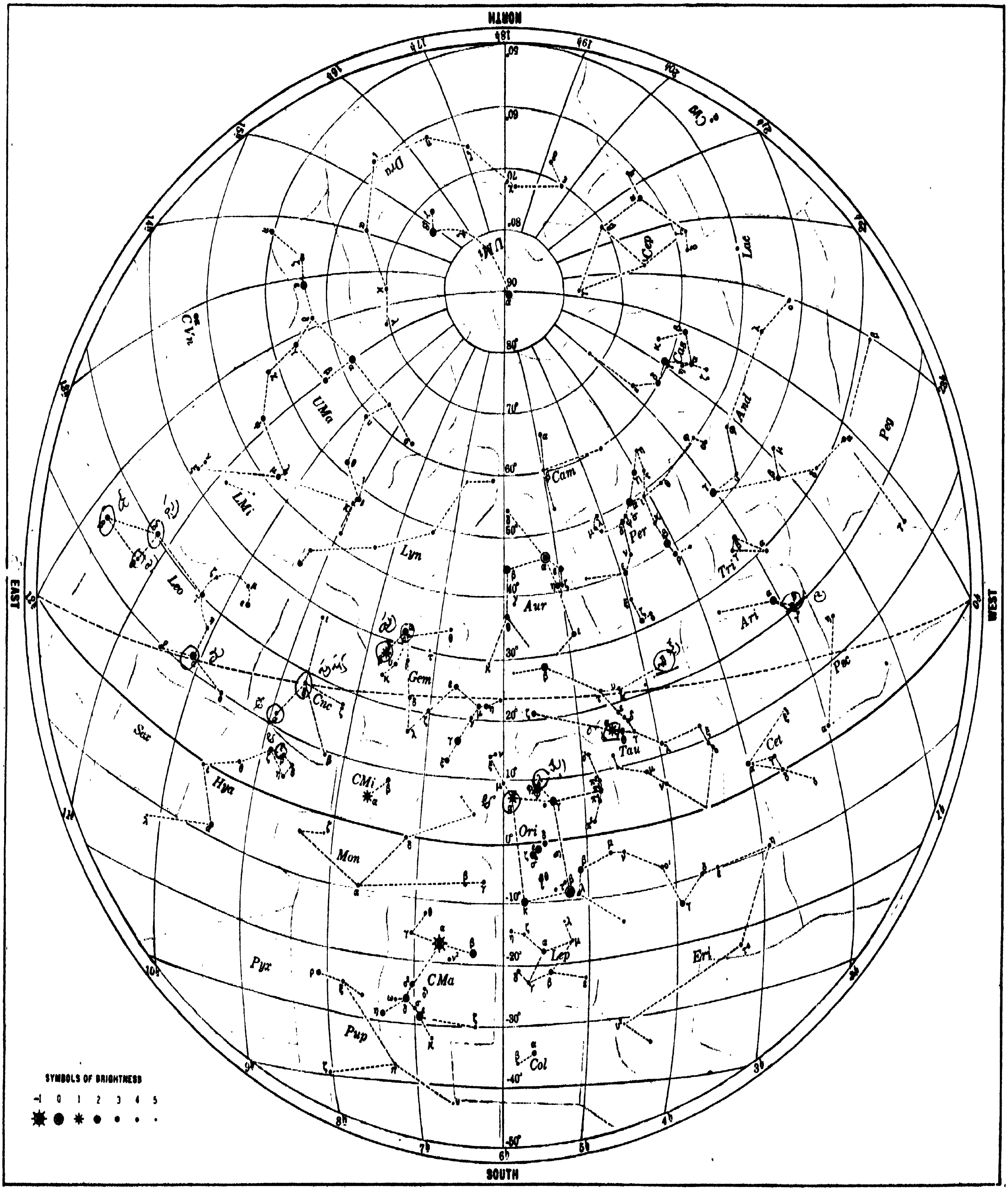
The **right ascension** (abbreviated R. A.) of a point on the celestial sphere is the arc of the celestial equator between the vernal equinox and the hour circle which passes through the point, the arc being measured from the vernal equinox eastward.

The **declination** (abbreviated Dec.) of a point on the celestial sphere is its angular distance from the celestial equator. It may be either plus (north) or minus (south).

Right ascensions are usually expressed in hours, minutes, and seconds (as longitudes sometimes are) from 0 to 24 hours, 15 degrees (the angle through which the celestial sphere turns in one sidereal hour) being equivalent to 1 hour. The hour circles shown on the charts are those of each whole hour of right ascension. The hour corresponding to each circle is marked at the edge of the chart. These are but twenty-four of the infinite number of hour circles which might be drawn. One may be drawn to pass through any point. The right ascension of any point is also the angle between the hour circle through the vernal equinox and the one through the point, counting eastward from that through the vernal equinox.

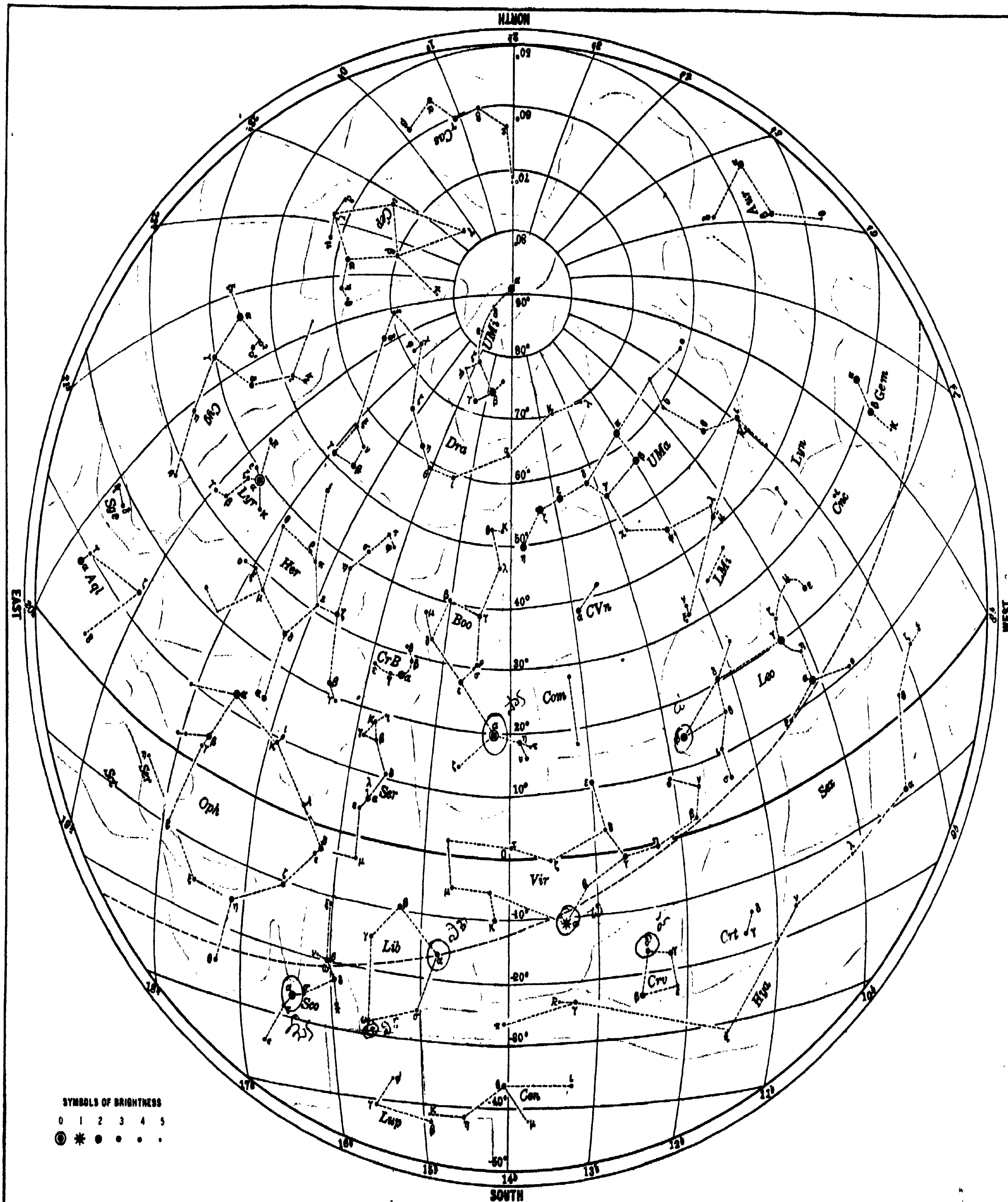
Parallels of declination are drawn for each 10 degrees of declination. The number of degrees of declination corresponding to each of these parallels is shown on the straight line passing through the center, the pole, and

DETAIL CHART A



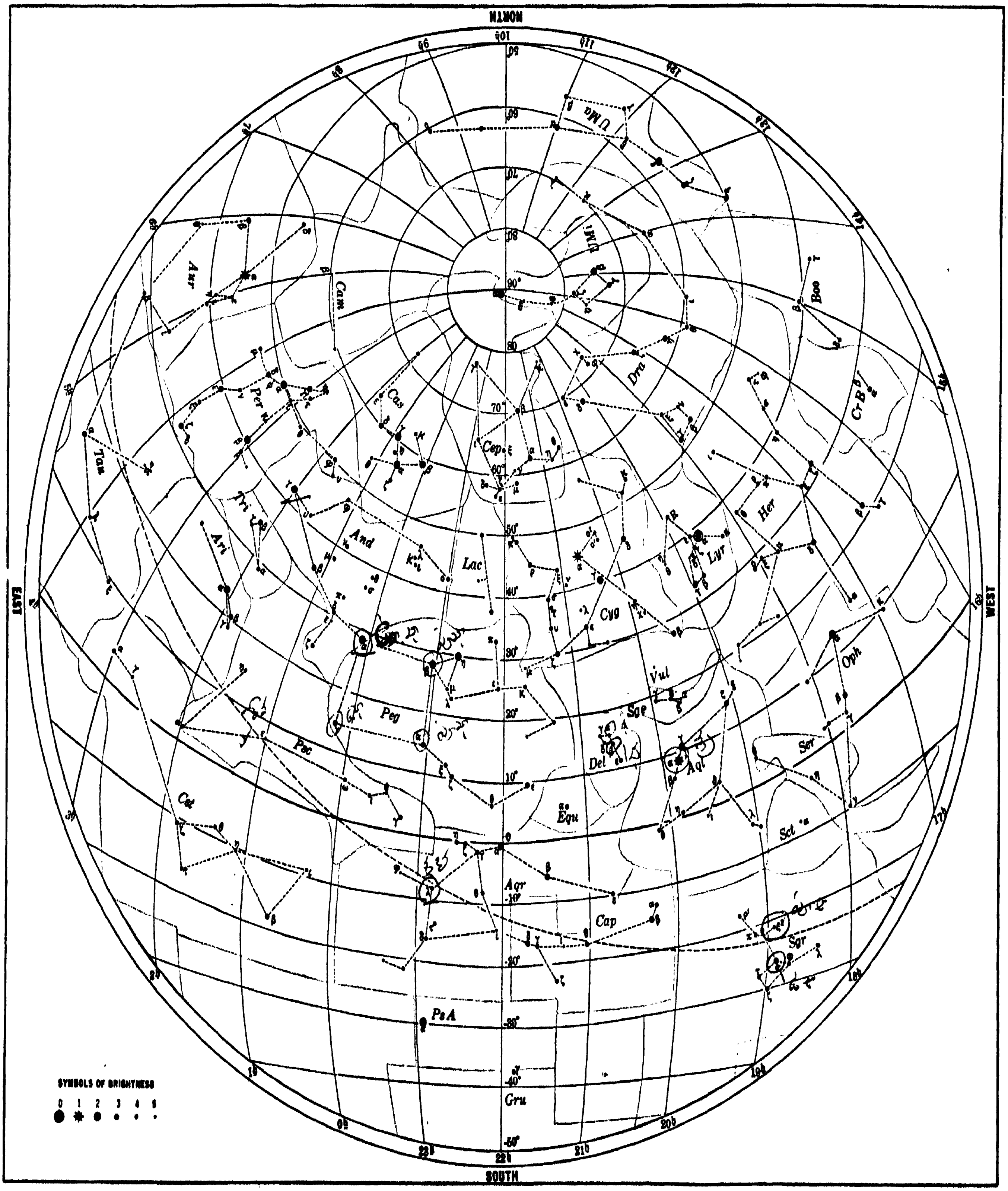
For use with Charts 1, 2, 3, and 12
For right ascensions between 2 hours and 10 hours

DETAIL CHART B



For use with Charts 4, 5, 6, and 7
For right ascensions between 10 hours and 18 hours

DETAIL CHART C



For use with Charts 8, 9, 10, and 11
For right ascensions greater than 18 hours and those less than 2 hours

15403

the north and south points on each detail chart. This straight line represents the celestial meridian.

The parallels of declination are the paths along which the stars on these circles move as the celestial sphere turns. The celestial sphere turns at such a rate that each of the hour circles shown moves to the position of the one west of it in a sidereal hour. The celestial meridian, however, does not move. A sidereal hour is about 10 seconds shorter than a mean solar hour. The hour circles cross the meridian in the order 0^h, 1^h, 2^h, 3^h, and so forth. When 0^h crosses, it is sidereal noon, and the **sidereal time** at any instant is the right ascension of the hour circle then on the meridian.

Because of the precession of the equinoxes, the right ascension and declination of any point change—but very slowly. These charts are based on the equinox of 1950. Their error at the present time is trifling.

As these charts are to be read and used indoors, they have been printed, black on white, which is more suitable for such purposes than a dark background.

Chart A represents the sky as it is at 9 p. m. (local time) Feb. 5. It is the best chart to use for objects with right ascensions between 2 and 10 hours. Chart *A* should be used in connection with charts 1, 2, 3, or 12.

Chart B represents the sky as it is at 9 p. m. June 6. It is the best chart to use for objects with right ascensions between 10 and 18 hours. Chart *B* should be used in connection with charts 4, 5, 6, or 7.

Chart C represents the sky as it is at 9 p. m. Oct. 6. It is the best chart to use for objects with right ascensions greater than 18 and for those with right ascensions less than 2 hours. Chart *C* should be used in connection with charts 8, 9, 10, or 11.

Only a few of the stars shown on charts 1 to 12 are not to be found on the proper chart *A*, *B*, or *C*, and these are either faint stars or stars which do not rise far above the southern horizon and which are visible for a short time only. The stars in the latter group may be found on the detail chart of Part III.

Example.—What is the right ascension and declination of Aldebaran (α Tauri)?

From Chart *A* it may be seen that this star lies between the hour circles marked "4^h" and "5^h;" by estimation, it is decided that the right ascension is approximately 4 hours and 33 minutes. It may be seen that the star lies between the parallels of declination marked "10°" and "20°," and it is estimated that the declination is 16 degrees (north).

THE NAUTICAL ALMANAC

The *American Nautical Almanac* is the title of a pamphlet issued for each year by the Nautical Almanac Office, U. S. Naval Observatory. It gives the right ascension and declination of the Sun, Moon, Venus, Mars, Jupiter, and Saturn for each day of the year, also information about the stars, eclipses, and so forth. To secure it, one should send 15 cents (not stamps) to the Superintendent of Documents, Government Printing Office, Washington, D. C., stating the year for which the almanac is desired. It may be secured for at least a year in advance. By using this pamphlet, each of the planets, Venus, Mars, Jupiter, and Saturn can easily be located at any time.

Example.—Where shall I look for Mars, Nov. 16, 1928?

The *Nautical Almanac* for 1928, page 85, shows that the right ascension of Mars on this day is $6^h40^m29^s$ and that its declination is $+24°45'.6$. Since the R. A. is between 2^h and 10^h, Chart *A* is the proper one to use. Using this chart, plotting the position of the planet, it is found to be just south of the star ϵ Geminorum. Table II, page 10, shows that Gemini is in its best position on Chart 2, and it is discussed in connection with that chart. Table 1, page 7, shows that Chart 2 fits the sky at 3 a. m. on Nov. 15, which is the nearest date to Nov. 16, given in the table. Hence, on this date, Mars will be seen best at about 3 a. m., but it can be seen in a somewhat less favorable position for several hours before and after this time.

There are several ways of simplifying the solution. The last column of the page of the almanac is marked "Transit Meridian of Greenwich." This gives the time when Mars is on the meridian at Greenwich. The time of crossing the meridian elsewhere differs from this by only a few minutes, at most. For Mars on Nov. 16 it gives as this time 3^h1^m. That is, Mars is south and in its best position at 3:01 a. m., which agrees with our previous result. If Mars is far north of the equator, as it is at that time, it rises between 7 and 8 hours before it reaches the meridian and sets after the same interval, but if it is far south, the interval is reduced to 4 hours.

If the time given in the almanac is less than 12^h the time is a. m., but if greater the time is p. m. and one should subtract 12 hours and mark the result p. m.; thus 21^h17^m means 9:17 p. m. If the time of crossing the meridian falls in daylight hours and not within about 2 hours of noon (12^h) the planet may be seen nevertheless, in the early evening if the time is later than noon and in the early morning if earlier than noon.

Since the planets are nearly always in one of the twelve zodiacal constellations, we restate here, for convenience, the number of the chart on which each of these is in its best position, namely:

Aries	12	Libra	6
Taurus	1	Scorpius	7
Gemini	2	Sagittarius	8
Cancer	3	Capricornus	9
Leo	4	Aquarius	10
Virgo	5	Pisces	11

A knowledge of the constellations is not of great help in finding Mercury, since that planet can be seen only in twilight, when only very bright stars are visible. This planet can be seen low in the western part of the sky for a few days before or after its greatest eastern elongations and in the east before sunrise near its greatest western elongations. The times of these elongations will be found on the page of the almanac headed "Planetary Configurations," page 104, in 1928. By **elongation**, is meant the angle between the direction of the planet and that of the sun.

After Jupiter and Saturn have been found, they are easily followed from night to night, as they change their positions slowly, and this is usually true of Mars. Venus and Mercury often move very rapidly, but the brightness of Venus enables one to follow it easily.

The positions of comets and other unusual objects will not be found in the Nautical Almanac. The positions of newly discovered comets may be secured from astronomers, but in general, the amateur must depend upon newspapers, Associated Press dispatches, and the like for his information about them. If the comets are visible for several months, information may be obtained from astronomical publications. It must be borne in mind that comets move and that this motion is most rapid when they are near the earth and brightest. They can be located from their right ascensions and declinations by the method used for locating Mars.

The position of Polaris cannot be read easily from the charts. Its right ascension is 1^h44^m, and its declination, 89°2′.

At 9 p. m., Chart *A* is best from Dec. 6 to Apr. 7; Chart *B*, from Apr. 7 to Aug. 6; and Chart *C*, from Aug. 6 to Dec. 6.

PART III

THE CONSTELLATIONS NOT VISIBLE FROM THE UNITED STATES

Some who have learned the constellations on the charts of Part I, may travel to places from which they can see those which are farther south. Others may be interested in the southern stars who do not expect to see them. For the convenience of such persons and for the sake of completeness, two charts are added, one showing the stars visible from the south pole of the earth and made on the same plan as charts 1 to 12, and one showing details on the same plan as charts *A*, *B*, and *C*. At the south pole of the earth the south celestial pole is at the zenith and, therefore, at the center of the chart, and the celestial equator coincides with the horizon. The stars not seen on the other charts are in their best positions on these. It is not expected that the observer will be at the south pole, but the plan of allowing for absorption has been adhered to, as that method of plotting reduces the number of stars shown and relieves congestion. At the south pole, the stars move in circles parallel to the horizon, and the same stars—those south of the equator—are above the horizon at all times; hence, no statement of time is necessary. Since the center of the chart is the south pole, south means toward the center and north, away from it, when referring to these charts.

The stars are not so well distributed on these charts as on the others. They are strongly concentrated along the Milky Way, which is bright and complicated. The brightest three stars in the whole heavens are south of the equator. In order of decreasing brightness, they are Sirius in Canis Major, Canopus in Carina, and Alpha Centauri. They stand out very prominently on the charts and in the sky and are commonly used as reference points. Each of these charts contains 343 stars, whereas, as shown on page 11, the largest number shown on any chart of Part I is 277. The atmospheric absorption eliminates 135 stars of magnitude 4.5 or brighter from appearing on these charts. Thus, there are 478 stars of magnitude 4.5 or brighter south of the equator, while there are approximately 400 such stars north of the equator. The southern hemisphere, then, is 20 per cent richer in such stars than the northern.

CONSTELLATION NAMES

Table VIII is the extension of Table II, page 10, and Table VII, page 51. All constellations not in Table II, 27 in number, are in this table. Six of the constellations, all of which happen to be south of the equator, have no stars bright enough to be shown on any chart. They are Antlia, Cælum, Mensa, Microscopium, Sculptor, and Sextans. Their brightest stars, respectively, are of magnitudes 4.4, 4.5, 5.1, 4.7, 4.4, and 5.2. Their names (abbreviated) and their boundaries are shown on the detail chart but not on the other. In some cases, the meaning given does not correspond fully to the Latin name, for the reason that the original Latin name has been abbreviated in present usage; thus, the original name of Antlia (pump) was *Antlia Pneumatica*, which means "air pump," and that of Volans (flying) was *Piscis Volans*, which means "flying fish." As may be noted, the names differ in character considerably from those in Table II, a much larger proportion of them being those of inanimate objects. Only two, Ara and Corona Australis, are in Ptolemy's list of constellations. Those who formed and named the ancient constellations lived too far north to see the stars near the south pole of the sky and so, did not form constellations to include them. The large constellation, Argo, has been separated to form four constellations—Carina, Puppis, Pyxis, and Vela—and the name "Argo" has been abandoned. The assignment of Greek letters, however, except in Pyxis, remains as it was in Argo.

The number of stars stated in Table II does not necessarily apply to the constellations as found in Part III. When the numbers are larger in this part, due to the more favorable position of the constellations, they are restated and are as follows: Centaurus, 31; Columba, 5; Grus, 9; Lupus, 17; Phœnix, 9; Piscis Austrinus, 4; Pyxis, 3; Puppis, 17; Sagittarius, 18; Vela, 18. Scorpius has 21 stars, and 2 different stars appear on Chart 7. There are 16 in Eridanus, and 8 different ones are shown on Chart 1. Capricornus contains 1 star not shown on Chart 9, which is a better chart for this constellation.

The charts of Part III and those of Part I have 114 stars in common and together show 813 different stars. The brightest star not shown on at least one of the charts is of magnitude 4.3.

Table IX includes the additions needed to Table IV, page 12. The last three stars are included because of their brightness and importance. They do not have special names in common use. Alpha Centauri is sometimes called "Rigil Kentaurus," meaning the "centaur's foot," and Alpha Crucis is sometimes called "Acrux"—a coined word, no doubt.

TABLE VIII.—CONTINUATION OF TABLES II AND VII, PAGES 10 AND 51

Name	Pronunciation	Meaning	Number of stars	Genitive	Pronunciation	Abbreviation
Antlia	Ant'li-a	air pump	0	Antliæ	Ant'li-ē	Ant
Apus	Ā'pus	bird of paradise	4	Apodis	A-pō'dis	Aps
Ara*	Ā'ra	altar	8	Aræ	Ā'rē	Ara
Cælum	Sē'lum	graving tool	0	Cæli	Sē'lī	Cae
Carina	Ka-rī'na	keel	28	Carinæ	Ka-rī'nē	Car
Chamæleon	Ka-mē'lē-on	chameleon	4	Chamæleontis	Ka-mē-lē-on'tis	Cha
Circinus	Ser'si-nus	compasses	3	Circini	Ser'si-nī	Cir
Corona Australis*	Ko-rō'na As-trā'lis	southern crown	3	Coronæ Australis	Ko-rō'nē As-trā'lis	CrA
Crux	Kruks	cross	9	Crucis	Kroo'sis	Cru
Dorado	Do-ra'do	gold fish	5	Doradus	Do-rad'us	Dor
Horologium	Hor-o-lō'ji-um	clock	1	Horologii	Hor-o-lō'ji-ī	Hor
Hydrus	Hy'drus	water snake	5	Hydri	Hy'drī	Hyi
Indus	In'dus	indian	2	Indi	In'dī	Ind
Mensa	Men'sa	table mountain	0	Mensæ	Men'sē	Men
Microscopium	Mī-krō-skō'pi-um	microscope	0	Microscopii	Mī-krō-skō'pi-ī	Mic
Musca	Mus'ka	fly	6	Muscæ	Mus'kē	Mus
Norma	Nor'ma	level	1	Normæ	Nor'mē	Nor
Octans	Ok'tanz	octant	3	Octantis	Ok-tan'tis	Oct
Pavo	Pā'vō	peacock	11	Pavonis	Pā-vō'nis	Pav
Pictor	Pik'tor	easel	3	Pictoris	Pik-tor'is	Pic
Reticulum	Re-tik'u-lum	net	5	Reticulii	Re-tik'u-lī	Ret
Sculptor	Skulp'tor	sculptor's workshop	0	Sculptoris	Skulp-tor'is	Scl
Sextans	Seks'tanz	sextant	0	Sextantis	Seks-tan'tis	Sex
Telescopium	Tel-e-skō'pi-um	telescope	2	Telescopii	Tel-e-skō'pi-ī	Tel
Triangulum Australe	Trī-ang'gu-lum As-trā'lē	southern triangle	5	Trianguli Australis	Tri-ang'gu-lī As-trā'lis	TrA
Tucana	Tu-kā'na	toucan	4	Tucanæ	Tu-kā'nē	Tuc
Volans	Vō'lanz	flying fish	6	Volantis	Vō-lan'tis	Vol

TABLE IX.—CONTINUATION OF TABLE IV, PAGE 12

Name	Pronunciation	Constellation	Magnitude	Distance in light years	Luminosity
Achernar	A-ker'nar	Eridanus	0.6	67	209
Canopus	Ka-nō'pus	Carina	−0.9	652	77,000
Alpha Centauri	Sen-taw'rī	Centaurus	0.1	4.3	{ 1.12 0.32
Beta Centauri	Sen-taw'rī	Centaurus	0.9	91	305
Alpha Crucis	Kroo'sis	Crux	1.0	109	{ 27 142

Other bright stars not contained in Table V with their magnitudes are Beta Crucis, 1.5; Gamma Crucis, 1.6; Epsilon Carinæ, 1.7; Beta Carinæ, 1.8; and Alpha Trianguli Australis, 1.9.

THE MAGELLANIC CLOUDS

The Milky Way is represented on the chart of the southern constellations, as it was on the charts of Part I, by a large number of small dots. In addition to the Milky Way in the southern hemisphere there are two cloudy patches which resemble the Milky Way in appearance but which are too far from it to be considered parts of it. They are called the "larger Magellanic Cloud" and the "smaller Magellanic Cloud," from the name of the early navigator who described them. They are also called "nubecula major" and "nubecula minor." The larger one is on the border line between Dorado and Mensa, and the smaller one is in Tucana. Both consist of a mixture of faint stars, nebulæ, and star clusters. The distance of the larger cloud is found by Dr. Harlow Shapley, Director of the Harvard College Observatory, to be 112,000 light years and that of the smaller, 104,000 light years. He estimates that there are 500,000 stars in the smaller cloud, which can be detected, and that about 10,000 are more than a thousand times and perhaps 400, more than 10,000 times as bright as the sun. From that distance, the

sun would appear as a star of magnitude 22, which is just at the limit of our most powerful telescope. These clouds are clearly seen with the naked eye, the larger cloud being somewhat brighter. They are believed to be systems of stars entirely outside the system in which we are, that is, other universes. They are smaller than ours, however. The observer sees them as they were 100,000 years before, and, conversely, an observer from one of these clouds would see the sun as it was 100,000 years before, if, indeed he could see it at all. Excepting the nebula in Andromeda, see page 41 which is scarcely visible to the naked eye, the Magellanic Clouds are the most remote objects which can be seen without the aid of a telescope. When face to face with these objects, contemplating the facts which have been cited about them, one must be callous indeed who is not stirred to deep thoughts and to reverent and ennobling feelings.

The constellations of Table VIII and such of Table II as seem to need additional comment, will now be discussed in alphabetical order in connection with the charts.

CHART OF THE SOUTHERN CONSTELLATIONS

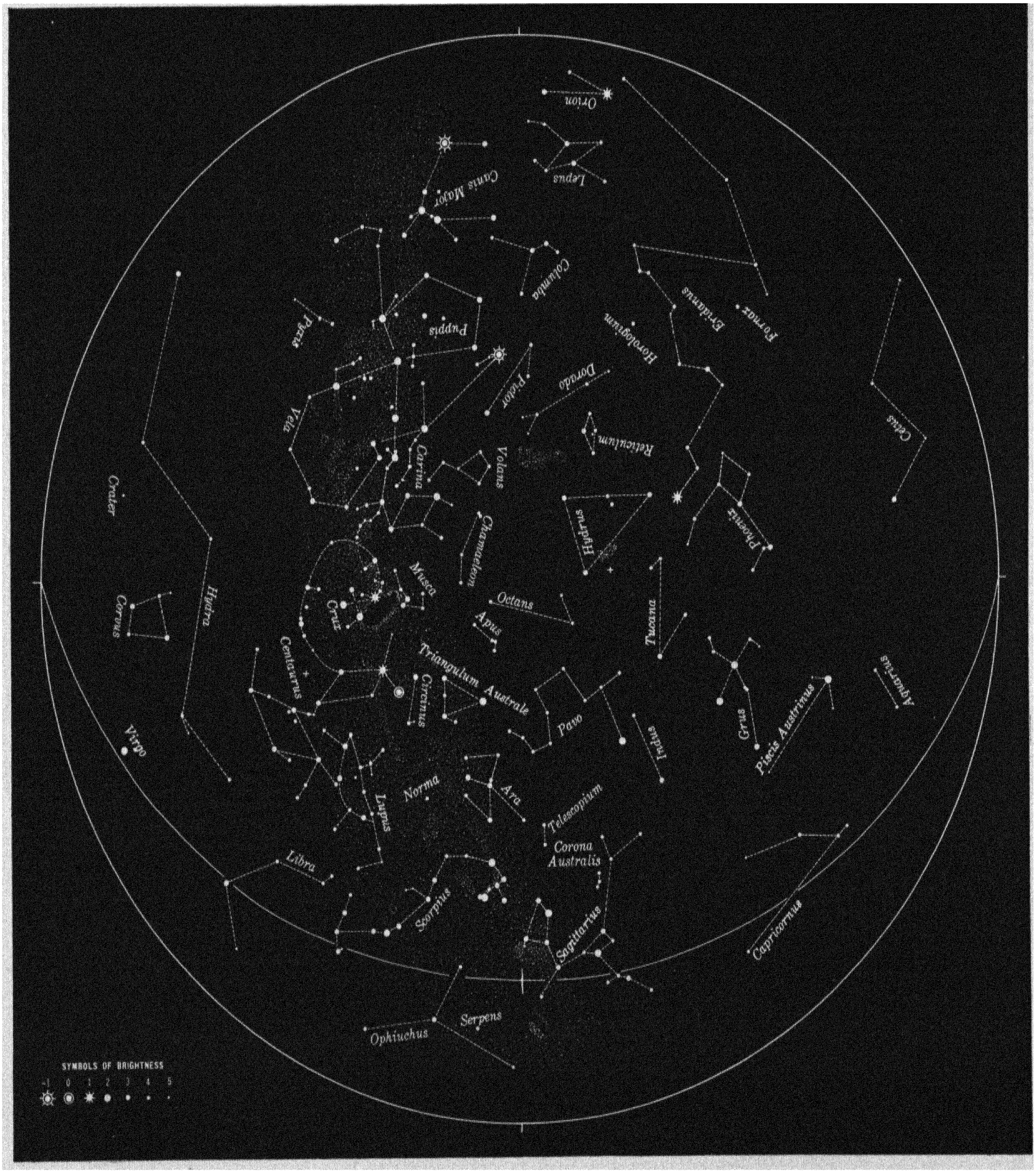


CHART OF THE SOUTHERN CONSTELLATIONS

The following are the stars brighter than magnitude 1.5 shown on the chart:

SIRIUS in Canis Major
CANOPUS in Carina
ALPHA CENTAURI in Centaurus
RIGEL in Orion
ACHERNAR in Eridanus
BETA CENTAURI in Centaurus
ALPHA CRUCIS in Crux
SPICA in Virgo
ANTARES in Scorpius (near ecliptic)
FOMALHAUT in Piscis Austrinus
BETA CRUCIS in Crux (in the short arm)

ANTLIA

This constellation contains no stars bright enough to be shown on the chart and no objects of much interest. Its position can be seen from the detail chart. It is on the upper left-hand side of the chart.

APUS

Apus is a close, circumpolar constellation. It consists of four stars of nearly the same brightness three of which are closely clustered. Opera glasses will resolve Delta Apodis, the star next to the isolated star, into two. The constellation can be located easily after the brighter constellation, Triangulum Australe, which is just north of it has been learned.

ARA

Ara lies just south of the end of the tail of Scorpius. The stars are arranged in the form of a twisted trident, with a pair of stars where the handle is attached. It is an ancient constellation.

CÆLUM

Cælum is a small constellation adjoining Columba and Eridanus. It contains no stars bright enough to be shown on the charts and no objects of great interest. Its boundary and name are marked on the detail chart.

CARINA

Of course, everyone will find Carina by first locating Canopus, its brightest star. Since Canopus is the second brightest star of all, being surpassed by Sirius only, it is very easily found. Canopus, however, is far away in one corner of the constellation. On the chart, Canopus is joined to a star which is at the foot of the **False Cross.** This False Cross is a group of four stars, two in Carina and two in Vela, which are so situated that they suggest the form of a cross. The arms of the cross are parallel to those of the real Southern Cross, Crux. The False Cross is somewhat larger and better formed than the real one, and is sometimes mistaken for it. A stream of five fainter stars runs from the star at the foot of the False Cross toward a diamond of stars. The last of the five is l Carinæ which varies in brightness from magnitude 3.6 to 5.0 and back in a period of 35.5 days. The star next to it in the stream is R Carinæ, which varies from magnitude 4.5 to 10.0 and back in a period of 309 days. It will usually be invisible to the naked eye.

Another series of five faint stars is shown extending away from the diamond. The third of these is the most celebrated of all variable stars, Eta Carinæ, or "Eta Argus," as it was formerly called. When first mentioned, in 1677, it was of the fourth magnitude. Several observers later noted it as of the second magnitude. Its variability was discovered in 1827, when it became very bright. In 1843, it was brighter than any star except Sirius, and it remained among the very brightest of stars until it dropped to the second magnitude in 1858. It declined to the third magnitude in 1859 and became invisible to the naked eye in 1868. By 1886, it had reached magnitude 7.6, and it has remained practically stationary at that magnitude since. It may or may not resume its variability —no one can tell what to expect of it. The star is in the midst of a nebulous region and midway between the two crosses.

One very naturally expects to learn that a star as brilliant as Canopus is comparatively near to us, but such is not the case. It is so far away that we cannot determine its distance with much accuracy. As is shown in Table IX, the most reliable value which can be stated is 652 light years. If this distance is correct, the luminosity of Canopus is 77,000. This is larger than that of Rigel, the greatest in Table IV. We are at least sure that the luminosity is enormous. The apparent brightness of stars is not found to be a very good clue as to their distances. Some very bright stars, such as Canopus, Rigel, and Deneb are very remote, and some very faint ones are found to be much nearer. Canopus, however, does not have the greatest luminosity known. This distinction is held by a star of ninth magnitude in the larger Magellanic Cloud, S Doradus, to which Shapley attributes the luminosity of 600,000. At the distance of the sun, this star would be about as much brighter than the sun as the sun is brighter than the full moon.

Sirius, the brightest fixed star, on the other hand, is a star which is close to us. Its luminosity is only 28, and many stars in Table IV surpass it. Canopus is seventy-four times as far away but has a luminosity 2,750 times as great, and that largely compensates. Canopus was the name of the chief pilot of the Argonautic expedition, which sailed in the ship Argo.

CENTAURUS

Those who wish to find Centaurus will look for its brightest star, Alpha Centauri, which is the third brightest in the whole sky. Although a very bright and famous star, it has no special name in common use. Beta Centauri, another bright star, is nearby. This pair is easily recognized. The line joining them points to Crux, the Southern Cross, for which reason they are called the **Southern Pointers.** Beta Centauri is at one end of a large arc of stars, which encloses Crux, the Southern Cross, and it is also at one corner of a parallelogram. There is a diamond formed by the brighter stars in the northern part of the constellation. The symbol + marks the position of the most magnificent of all globular star clusters. It appears to the naked eye as a hazy star of the fourth magnitude and is known as "Omega Centauri." Large telescopes are required to show its beauty. The distance of the cluster has been determined to be the least of any of the some seventy globular clusters, namely 21,000 light years. Thirty-one stars are shown, the greatest number in any constellation.

Alpha Centauri is widely known, even where the star is never seen, because, as far as is known it is the nearest star to us, excepting the sun. Its great brightness and its relatively rapid change of position among the stars (3.″68 a year) led astronomers to suspect that it was near. Its distance was first determined by Henderson and announced in 1839, just 2 months after Bessel had announced his determination of the distance of 61 Cygni. These were the first acceptable determinations of the distances of stars. Ten stars are now known which are nearer than 61 Cygni, a star of magnitude 5.1. The distance of Alpha Centauri is 4.3 light years, which is about twenty-five million million miles and 272,000 times the distance of the sun. Alpha Centauri is well known as a double star. About 2 degrees from it is a star of magnitude 10.5, which has very nearly the same motion as the two bright stars and is apparently a third member of the system. The determinations show that this faint star is a little closer than the other two, and it is known as **Proxima,** or *Proxima Centauri*, the name, of course, suggested by the Latin adjective which means "nearest."

Alpha Centauri is the finest of double stars. It is composed of two stars of magnitudes 0.33 and 1.70, even the fainter being brighter than the brighter component of Castor, the best northern double star. It was the fifth double star to be discovered, being found in 1685. It is a binary star, that is, a double star in which we can notice that the stars are influenced by each other's attraction and are moving in orbits about the center of mass of the two. The stars make a complete revolution in 78.8 years. The first measures of position were made in 1752, and the first accurate ones begin with 1834. More than two revolutions have been completed since 1752. The orbits are long ellipses. The distance between the two stars varies from 11. 4 to 35 times the distance from the earth to the sun. The distance between the two in angle varies from 2″ to 22″. When far apart, they are easily separated with a very small telescope. In 1927, the distance was 8″. The stars will be closest in 1956. The two stars are respectively 1.1 and 0.3 times as bright as the sun and 1.1 and 0.9 times as massive. Viewed from the distance of Alpha Centauri, our nearest neighbor, the sun would appear as a star of magnitude 0.45, which is nearly the same as that of the brighter component, and still nearer that of Procyon. The brighter component of Alpha Centauri is thus similar to the sun in brightness and mass, and it is also like it in other characteristics.

CHAMÆLEON

Chamæleon is a close circumpolar constellation. Four stars, which are nearly equal in brightness, are shown. The most striking detail is the close pair of stars at one end of the line of stars. The long arm of the Southern Cross, extended two and a half times, ends nearly at the star at the other end of the line.

CIRCINUS

The three stars of this constellation are very easy to find, as they lie just beside the very bright star Alpha Centauri.

COLUMBA

Columba is easily found, as it lies on the line from the brilliant Rigel in Orion to the still more brilliant Canopus in Carina. The stars are joined in the form of a Y.

CORONA AUSTRALIS

The three stars of this constellation lie close together nearly in a straight line, south of the Dipper in Sagittarius. There are other fainter stars, which make up a semicircle. Although an inconspicuous constellation, it is one of the ancient ones.

CRUX

Crux is the most celebrated of the constellations of the far south, usually called the **Southern Cross.** There is no other cross in the heavens in the names of constellations, but a group in Cygnus is often

called the "Northern Cross." The four principal stars in the constellation, of course, form the cross, as may be seen from the chart. The stars forming it are of unequal brightness, and a fifth star in the vicinity spoils the effect. The configuration more closely resembles a kite than a cross. It lies nearer to the south pole than any other well-defined and conspicuous group and thus has an importance corresponding to that of the Big Dipper in the northern hemisphere. Northern observers are usually disappointed with it. Some may be interested in reading Mark Twain's impressions upon seeing the Southern Cross for the first time, recorded in "Following the Equator," Chap. 5. The brightest star of the cross is Alpha Crucis, which is at the foot of the Cross. It is a magnificent double star when seen in a telescope, the finest excepting Alpha Centauri. The two stars are of magnitudes 1.6 and 2.1, the brighter component being a little brighter than the fainter one of Alpha Centauri. There is a star of magnitude 5.1 only 90″ away. The star at the other end of the long arm is Gamma Crucis, an orange-colored star. The brighter of the stars in the short arm is Beta Crucis, and the fainter is Delta Crucis. The star north of Beta Crucis, Mu Crucis, is composed of two stars of magnitudes 4.3 and 5.5, 34″ apart, easily separable with a very small instrument.

The south pole lies nearly on the straight line from the brightest star in Hydrus, Beta Hydri, to Alpha Crucis, about a third of the way from the former star. It is also about midway between Achernar in Eridanus and the Cross. The Milky Way comes closest to the south pole in Crux. Just beside the cross is a very singular rift in the Milky Way, known as the **"coalsack."** It is a very dark, pear-shaped spot in the midst of a brilliant section of the Milky Way, like an island in its stream. It seems darker than it really is, by reason of the contrast. There are within it a faint, naked-eye star and plenty of telescopic stars. This is but one, the most conspicuous, of many such rifts in the Milky Way. Another in Cygnus is called the "northern coalsack." These dark places are due to great masses of opaque matter, which prevent us from seeing the stars which lie back of them. They are now known as "dark nebulæ." The name "coalsack" was applied by early mariners. The length of the long arm of the cross is six degrees. Although so important, Crux is one of the smallest constellations.

DORADO

This arrow-shaped constellation lies about a third of the way from Canopus in Carina to Achernar in Eridanus. In the southern end, running over into Mensa, lies the larger Magellanic Cloud, also called "nubecula major," described on page 59.

The middle star of the five shown is Beta Doradus, a star which varies about a magnitude in brightness in a period of ten days. It is a variable of the Delta Cephei type and the brightest of that type in the southern hemisphere.

ERIDANUS

Eridanus is such a long constellation and extends so far in the north-south direction, that only the southern part can be seen well on these charts and the northern part only on the charts of Part I. The brightest star of the constellation, Achernar, is at one end of the stream of stars in the constellation, and, appropriately, the name *achernar* means the "end of the river." The river Eridanus has been associated with the Nile, the Euphrates, and other rivers. The next brightest star lies near Rigel in Orion, at the other end of the river. A small part of the constellation is north of the equator. The winding stream of stars is not difficult to trace out. The two pairs in the stream should be noted. The star north of these pairs also has a companion, still closer to it but just a little too faint to be shown. This constellation was also discussed on page 43.

GRUS

Grus contains two conspicuous stars of the second magnitude. A close pair of fourth-magnitude stars with the two bright ones make an equilateral triangle. Some of the stars lie in a gently curving stream, as shown on the figure. The constellation lies south of Fomalhaut, the bright star in Piscis Austrinus.

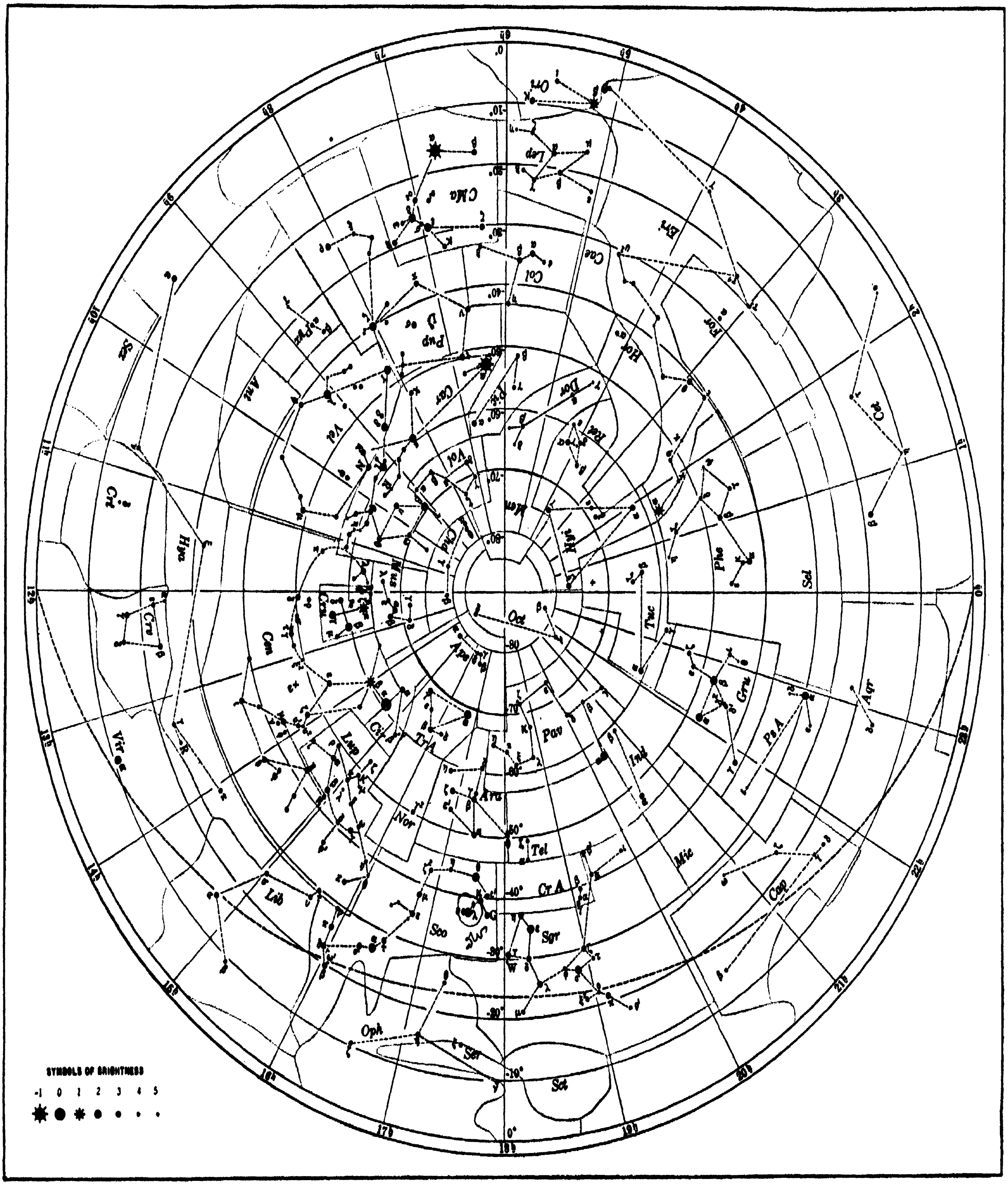
HOROLOGIUM

Only one star in this constellation appears. It can be located from its position with respect to the stars of the adjacent constellation Eridanus. It has a fainter companion. With the three pairs mentioned in Eridanus, this makes four in a very small section of the sky. The pair in Horologium is midway between Achernar in Eridanus and the diamond in Lepus.

HYDRUS

Hydrus is represented as a triangle with approximately equal sides, with a star at the middle point of one side. This side, if continued, would pass nearly through Achernar. Hydrus is a close, circumpolar constellation. The pole with the three stars in the triangle form a good parallelogram. Hydrus must not be confused with Hydra, a part of which is shown near the edge of the chart. Both are water snakes, Hydrus, male and Hydra, female. The Germans call Hydra the large water snake and Hydrus the small one. Hydra is an ancient constellation. The modern one should not have been given a confusing name.

DETAIL CHART OF THE SOUTHERN CONSTELLATIONS



INDUS

Only two stars of this constellation appear. They lie near the brightest star in Pavo.

LUPUS

Lupus is represented as an arc of stars resting upon a line of stars, with a few other scattered ones. The constellation is north of Alpha Centauri. A line from the pole through Alpha Centauri passes through Alpha Apodis, Alpha Circini, Alpha Centauri, and Alpha Lupi, and with but a slight bend, the same line will pass through Alpha Libræ. This is a remarkable coincidence.

MENSA

This is a close circumpolar constellation in which no stars are bright enough to be shown. The larger Magellanic Cloud lies partly within it. Its position is marked on the detail chart.

MICROSCOPIUM

This is another constellation in which no stars appear. It lies south of Capricornus.

MUSCA

Musca lies just south of the Southern Cross and therefore is easily found. *Musca* means "fly," the only insect found among the constellations.

NORMA

Only one star of Norma appears. A line from Alpha Crucis to Alpha Centauri extended an equal distance ends near this star.

OCTANS

Octans is important chiefly because of the fact that the south pole lies in it. Delta Octantis is the nearest star to the pole which is shown, but it is of magnitude 4.1 and more than 6 degrees away. Beta Hydri, magnitude 2.9, over 12 degrees away, is the nearest star as bright as the third magnitude. Beta Carinæ, magnitude 1.8, over 20 degrees away, is the nearest star as bright as Polaris, which is but a little over a degree from the north pole. A naked-eye star, Sigma Octantis, magnitude 5.5, is about 50′ from the south pole. Delta Octantis is the star just south of Apus.

PAVO

Pavo contains one star of the second magnitude. All of the others shown are of the fourth. Three stars with the bright one form the letter T. The others are arranged in the form of an S. The star in the middle of the S is Kappa Pavonis, a variable star. Its brightness changes from magnitude 3.8 to 5.2 and back in a period of 9.0 days.

PHŒNIX

This constellation contains a good diamond of stars with one diagonal pointing to Achernar in Eridanus.

PICTOR

This constellation is easily found, because of its proximity to Canopus in Carina.

PISCIS AUSTRINUS

A very brilliant star, Fomalhaut, and three faint stars represent this constellation. Fomalhaut, Achernar, and Alpha Pavonis form a large triangle with equal sides.

PUPPIS

If one of the stars of Vela be included as a corner, the brighter stars of Puppis will form a pretty regular pentagon with a star in the middle. If a line were drawn through the middle star and one corner, it would lead to Sirius in Canis Major, and one through another corner, to Canopus in Carina. The fainter star in the middle is L^2 Puppis, a red and variable star. Its brightness varies from magnitude 3.4 to 6.2 and back in a period of 140 days. There is a striking line of three stars in the corner toward Vela. The southernmost of the three is V Puppis, an eclipsing variable star. Its magnitude varies from 4.1 to 4.8 and back regularly in a period of 1.4 days. The star just north of the pentagon is near a cluster of faint stars.

PYXIS

A line from the middle star to one corner of the pentagon in Puppis, just mentioned, extended an equal length, ends in Pyxis. Only three stars are shown.

RETICULUM

Reticulum is represented as a small diamond of stars midway between Canopus in Carina and Achernar in Eridanus.

SAGITTARIUS

This constellation was discussed on page 35. The faint star near the quadrilateral on the left-hand side is W Sagittarii, a variable star the brightness of which varies from magnitude 4.3 to 5.1 and back in a period of 7.5 days.

SCULPTOR

No stars are shown in this constellation. Its position is marked at the right-hand side of the detail chart.

SCORPIUS

This constellation was discussed on page 33. The star south of the one where the branch leads off to two faint stars is Mu Scorpii, which can easily be seen with the naked eye to be double. The star south of this one has a star of magnitude 4.8 near it. The northernmost star shown, Beta Scorpii, is in small telescopes, an interesting double star.

TABLE X.—LIST OF SPECIAL STAR NAMES

Constellation	Greek letter	Special name	Constellation	Greek letter	Special name
Andromeda	α	Alpheratz	Draco	α	Thuban
Andromeda	β	Mirach	Draco	β	Alwaid
Andromeda	γ	Almach	Draco	γ	Etamin
Aquarius	α	Sadalmelik	Draco	ι	Ed Asich
Aquarius	β	Sadalsuud	Draco	λ	Giansar
Aquarius	γ	Sadachbia	Equuleus	α	Kitalpha
Aquarius	δ	Skat	Eridanus	α	Achernar
Aquarius	θ	Ancha	Eridanus	β	Cursa
Aquila	α	Altair	Eridanus	γ	Zaurac
Aquila	β	Alshain	Eridanus	η	Azha
Aquila	γ	Tarazed	Eridanus	θ	Acamar
Aries	α	Hamal	Eridanus	o^1	Beid
Aries	β	Sharatan	Gemini	α	Castor
Aries	γ	Mesartim	Gemini	β	Pollux
Auriga	α	Capella	Gemini	γ	Alhena
Auriga	β	Menkalinan	Gemini	δ	Wasat
Boötes	α	Arcturus	Gemini	ε	Mebsuta
Boötes	β	Nakkar	Gemini	ζ	Mekbuda
Boötes	ε	Izar	Gemini	η	Propus
Boötes	η	Muphrid	Hercules	α	Ras Algethi
Cancer	α	Acubens	Hercules	β	Korneforos
Cancer	γ	Asellus Borealis	Hydra	α	Alphard
Cancer	δ	Asellus Australis	Leo	α	Regulus
Canes Venatici	α	Cor Caroli	Leo	β	Denebola
Canis Major	α	Sirius	Leo	γ	Algeiba
Canis Major	β	Mirzam	Leo	δ	Zosma
Canis Major	δ	Wezen	Leo	μ	Rasalas
Canis Major	ε	Adhara	Lepus	α	Arneb
Canis Major	ζ	Furud	Lepus	β	Nihal
Canis Major	η	Aludra	Libra	α	Zubenelgenubi
Canis Minor	α	Procyon	Libra	β	Zubeneschamali
Canis Minor	β	Gomeisa	Lyra	α	Vega
Capricornus	α	Algedi	Lyra	β	Sheliak
Capricornus	γ	Nashira	Lyra	γ	Sulafat
Capricornus	δ	Deneb Algedi	Ophiuchus	α	Ras Alhague
Carina	α	Canopus	Ophiuchus	β	Cebalrai
Carina	β	Miaplacidus	Ophiuchus	δ	Yed Prior
Cassiopeia	α	Schedir	Ophiuchus	ε	Yed Posterior
Cassiopeia	β	Caph	Ophiuchus	η	Sabik
Cassiopeia	δ	Ruchbah	Ophiuchus	λ	Marfic
Centaurus	α	Rigil Kentaurus	Orion	α	Betelgeuse
Cepheus	α	Alderamin	Orion	β	Rigel
Cepheus	β	Alfirk	Orion	γ	Bellatrix
Cepheus	γ	Errai	Orion	δ	Mintaka
Cetus	α	Menkar	Orion	ε	Alnilam
Cetus	β	Deneb Kaitos	Orion	ζ	Alnitak
Cetus	ζ	Baten Kaitos	Orion	κ	Saiph
Cetus	o	Mira	Orion	λ	Meissa
Columba	α	Phact	Pegasus	α	Markab
Columba	β	Wazn	Pegasus	β	Scheat
Corona Borealis	α	Alphecca	Pegasus	γ	Algenib
Corona Borealis	β	Nusakan	Pegasus	ε	Enif
Corvus	α	Alchiba	Pegasus	ζ	Homan
Corvus	γ	Gienah	Perseus	α	Mirfak
Corvus	δ	Algorab	Perseus	β	Algol
Crater	α	Alkes	Pisces	α	Alrescha
Crux	α	Acrux	Piscis Austrinus	α	Fomalhaut
Cygnus	α	Deneb	Sagittarius	α	Rukbat
Cygnus	β	Albireo	Sagittarius	β	Arkab
Cygnus	γ	Sadr	Sagittarius	δ	Kaus Meridionalis

TABLE X.—LIST OF SPECIAL STAR NAMES.—(*Continued*)

Constellation	Greek letter	Special name	Constellation	Greek letter	Special name
Sagittarius	ε	Kaus Australis	Ursa Major	δ	Megrez
Sagittarius	λ	Kaus Borealis	Ursa Major	ε	Alioth
Sagittarius	σ	Nunki	Ursa Major	ζ	Mizar
Scorpius	α	Antares	Ursa Major	η	Alkaid
Scorpius	β	Graffias	Ursa Major	ι	Talitha
Scorpius	δ	Dschubba	Ursa Major	λ	Tania Borealis
Scorpius	λ	Shaula	Ursa Major	μ	Tania Australis
Serpens	α	Unukalhai	Ursa Major	ν	Alula Borealis
Serpens	θ	Alya	Ursa Major	ξ	Alula Australis
Taurus	α	Aldebaran	Ursa Minor	α	Polaris
Taurus	β	Nath	Ursa Minor	β	Kochab
Taurus	γ	Hyadum I	Ursa Minor	γ	Pherkad Major
Taurus	δ	Hyadum II	Ursa Minor	δ	Yildun
Taurus	η	Alcyone	Virgo	α	Spica
Ursa Major	α	Dubhe	Virgo	β	Zavijava
Ursa Major	β	Merak	Virgo	ε	Vindemiatrix
Ursa Major	γ	Phecda			

SEXTANS

Sextans is divided by the equator with a somewhat larger portion south of it. It contains no stars bright enough to be shown. Its position is marked at the left-hand side of the detail chart.

TELESCOPIUM

This constellation is represented by two stars. It lies just south of Sagittarius.

TRIANGULUM AUSTRALE

This name, meaning the "southern triangle," is very suitable; since the brightest three stars are so situated that they may be considered as being at the three vertices of an equilateral triangle. A fainter star lies at the middle of one side, and one lies outside the triangle. The constellation is easily found by setting out from the bright star Alpha Centauri.

TUCANA

Tucana is represented as a Z. It is easily found by setting out from Lupus or from Achernar in Eridanus. The cross + marks the position of the second-best globular star cluster. The object is known as 47 Tucanæ, 47 being a number assigned to it by Bode. On some charts, it is marked as Xi Tucanæ. It appears to the naked eye as a hazy star of magnitude 4.5. With a large telescope it is a wonderful object. Its distance is found to be 21,000 light years. Close beside it is the still more distant object, the smaller Magellanic Cloud discussed on page 59.

VELA

The manner of joining the stars needs no special comment, except to refer to the discussion of the False Cross under Carina and to the similarity in the arrangement of the two groups of three faint stars each along the northern boundary. Gamma Velorum, the star which forms a corner of the pentagon in Puppis, is celebrated as the only bright star which gives a bright line spectrum (Wolf-Rayet star). The fainter star between this and the one in the False Cross, Omicron Velorum, has several still fainter stars near it.

VOLANS

The stars in Volans are arranged in the form of a kite and its tail. None is bright. It lies in the direction of Alpha Centauri from Canopus in Eridanus.

CONCLUSION

Bayer's system of naming stars by using Greek letters is such a great improvement over the earlier method of giving special names to stars that it is very generally used. Those who now use special names usually resort to Bayer's Greek letters for identifying the stars on charts, in any case. Extensive use of special names is not recommended, but as names other than those used in this book (tables IV and IX) are frequently used in other books, a longer list of special names, arranged according to the constellations in alphabetical order, is given in Table X. The names in this table are not indexed.

The discussion of the constellations is now completed. The purpose of the book is to encourage observation. We hope that observation of the constellations may create a desire for more detailed observations, with an opera glass or a telescope. Many amateurs, with and without instruments, are now doing valuable work in observing the variations in the brightness of variable stars. Those who think that they may be interested

in making such observations should communicate with the American Association of Variable Star Observers, in care of Harvard College Observatory, Cambridge, Mass., and they will be given information regarding the work. Other amateurs are doing useful work in the observation of meteors. This is done largely without instruments. Those who wish information about this work should communicate with the American Meteor Society in care of Flower Observatory, University of Pennsylvania, Upper Darby, Pa. There are similar organizations in other countries.

Some may be interested in learning more about the heavenly bodies and astronomy in general than is contained in this book and may desire to have a few other good books suggested. For their benefit, a few will be named. They are not the only ones which might be approved but are merely suggestions. Only books "in print" are included.

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"Norton's Star Atlas and Telescopic Handbook," 4th ed. enlarged, Gall and Inglis, London, 1927.

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SERVISS, "Astronomy with an Opera Glass," D. Appleton & Company, New York, 1888.

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FATH, "The Elements of Astronomy," 2nd ed., McGraw-Hill Book Company, Inc., New York, 1928.

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RUSSELL, DUGAN, and STEWART, "Astronomy," Ginn and Company, New York, 1926, 1927, Vol. I, "The Solar System," Vol. II, "Astrophysics and Stellar Astronomy," sold separately.

Other books of which the titles indicate the nature are:

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"Amateur Telescope Making," Scientific American Publishing Company, New York, 1926.

BERRY, "A Short History of Astronomy," Charles Scribner's Sons, New York, 1899.

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Some of the least technical of the many periodicals devoted to astronomy are:

The Monthly Evening Sky Map, 367 Fulton St., Brooklyn, N. Y.

Popular Astronomy, Northfield, Minn.

Publications of the Astronomical Society of the Pacific, 803 Merchants Exchange Bldg., San Francisco, Calif.

Journal of the British Astronomical Association, Eyre and Spottiswoode, London, England.

Among other things, these magazines discuss current astronomical events.

Monthly articles on current astronomical events are contained in:

Science News-Letter, Washington, D. C.

Nature Magazine, Washington, D. C.

The Scientific American, New York, N. Y.

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Note.—**Boldface** type indicates principal reference; (m) mythology; (t) table.